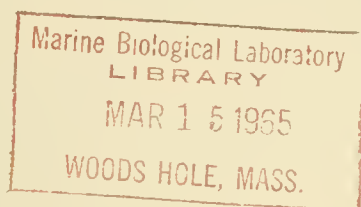


# Automatic Data Processing Program for Marine Synoptic Radio Weather Reports

By James H. Johnson, Glenn A. Flittner, and  
Marvin W. Cline



SPECIAL SCIENTIFIC REPORT-FISHERIES No. 503

UNITED STATES DEPARTMENT OF THE INTERIOR  
FISH AND WILDLIFE SERVICE



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BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, *Director*

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# Automatic Data Processing Program for Marine Synoptic Radio Weather Reports

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## INTRODUCTION

As part of a study of the distribution of north Pacific albacore, the staff of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, published monthly sea surface temperature charts of the eastern Pacific Ocean from 1957 through 1959. At the end of this phase of the north Pacific albacore investigations, the task of preparing and distributing the monthly charts was assumed by the staff of the Tuna Forecasting Program, Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.

The purpose of the sea temperature charts now is to provide current sea temperature information to the tuna fishing industry, marine scientists, and meteorologists. That the charts are providing useful data to these groups is evident from the work of Broadhead and Barrett (1964), Dickson (1964), Flittner (1963), Magill (1963), Namias (1959, 1963), Quast (1964), and others.

Charts prepared at the BCF Biological Laboratory at San Diego are circulated in two series. Monthly sea temperature charts are published in the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information. A 15-day temperature chart for use by albacore fishermen is published from April through October as a supplement to the above publication for a limited area of the temperate eastern Pacific. Monthly summaries and charts of meteorological variables and heat budget computations are circulated to a limited mailing list under the title "Summary of Marine Synoptic Weather Reports."

The purposes of this paper are to describe an automatic data processing program (ADP) for summarization of synoptic marine weather reports, to describe the sea temperature reporting program, and to provide information on procedures for calculating the energy exchange at the air-sea interface for the Pacific Ocean.

---

Note.--James H. Johnson, Oceanographer; Glenn A. Flittner, Fishery Biologist (Research); and Marvin W. Cline, Mathematics Technician, Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.

## SOURCES OF DATA

The first International Maritime Conference, called in Brussels, Belgium, in 1853, conceived the idea that cooperating governments should encourage routine weather observations on ships, and that nations should prepare and publish charts of ocean currents, prevailing winds, average sea and air temperatures, and storm tracks based on these and other data. Since inception of the program, weather reporting has played an increasingly vital role in the safe and efficient operation of ships at sea.

Data used in preparing the charts and summaries come from a variety of sources. The main source is the synoptic marine radio weather report from ships at sea. Additional data are provided by organizations that mail coastal and ocean temperatures to the San Diego laboratory for inclusion in the charts. Early in the sea temperature reporting program, it became apparent that use of ADP would be helpful in preliminary data screening for radio transmission errors, for coding errors, and for compiling an average of about 10,000-15,000 synoptic marine weather observations each month. After the feasibility of summarizing sea temperature data by ADP methods was established, it was expedient to broaden the program to compile other meteorological variables for use by scientists in marine climatology and other research studies. The elements for computation of the energy exchange at the air-sea interface were available from these summaries and monthly averages of this exchange by 5-degree quadrangles are now computed routinely.

The basic data utilized by the system described below is the "International Surface Report from Ship in Full Form, FM 21.A," approved by the World Meteorological Organization (WMO). Cooperating American and foreign-flag vessels make, record, and transmit the standard marine weather observations according to established procedures set up by WMO. Observations taken at 0000, 0600, 1200, and 1800 Greenwich Mean Time daily are transmitted to designated commercial and Government radio stations around the world (see U.S. Navy Hydrographic Office Publication No. 206, Radio Weather Aids, 1958).



Depending on geographical location, ships at sea report marine weather to designated receiving stations. North Pacific Ocean data for the region west of the 180th meridian are received by "Observer Tokyo." Data for the region east of the 180th meridian are received by "Observer San Francisco" and are relayed to the U.S. Weather Bureau Forecast Center at San Francisco International Airport, San Bruno, Calif. This center transmits both Observer San Francisco and Tokyo reports to other agencies via teletype circuits. The BCF Biological Laboratory, San Diego, maintains a drop on Service "O", Circuit 8274 to receive ship surface weather information 24 hours daily.

The ship weather report code adheres to the following symbolic 5-digit word group format:

YQL<sub>a</sub>L<sub>a</sub>L<sub>a</sub> L<sub>o</sub>L<sub>o</sub>L<sub>o</sub>GG Nddff VVwwW  
 PPPTT N<sub>h</sub>C<sub>L</sub>hC<sub>M</sub>C<sub>H</sub> D<sub>s</sub>v<sub>s</sub>app  
 OT<sub>s</sub>T<sub>s</sub>T<sub>d</sub>T<sub>d</sub> ld<sub>w</sub>d<sub>w</sub>P<sub>w</sub>H<sub>w</sub> ICE c<sub>2</sub>KD<sub>i</sub>re

Additional groups are coded when required; supplementary information following the ICE word group is usually transmitted in plain language. Definitions of symbols are given in table 1.

Since a large percentage of the incoming marine weather observations emanates from vessels having observers with limited meteorological experience, the question arises as to the validity of certain portions of the standard weather message. It is recognized that certain observational errors may be introduced by equipment in poor condition or through faulty operation. The problem of variability of ship's injection system thermometer readings, as an example, has been reviewed by Saur (1963). From his studies aboard U.S. Navy radar picket vessels, Military Sea Transport Service ships, and oil tankers, Saur found that the average injection temperature bias from that of a bucket temperature taken at the surface was about +1.20 F. In addition to instrument error, one complicating factor is that sea temperatures are not reported directly but, rather must be derived from air temperatures and air-sea temperature differences. In the near future the Commission on Maritime Meteorology of the WMO plans to discuss the possibility of changing the marine weather coding instructions so that sea temperature will be reported directly. Another complicating factor is the problem of communication errors. A study by Gibson (1962) for the Atlantic Ocean showed that 19 percent of the sea temperatures received on 1 day were incorrect; these errors were due to improper coding procedures, to communication transmission errors, and to faulty instruments.

Table 1.--Elements of the ship's surface synoptic code, FM 21.A<sup>1</sup>

Symbols	Definitions of symbols
Y	Day of week
Q	Octant of globe
L <sub>a</sub> L <sub>a</sub> L <sub>a</sub>	Latitude in degrees and tenths
L <sub>o</sub> L <sub>o</sub> L <sub>o</sub>	Longitude in degrees and tenths
GG	Greenwich civil time of observations, to nearest hour
N	Fraction of celestial dome covered by clouds
dd	Direction from which the wind is blowing (tens of degrees)
ff	Wind speed in knots
VV	Visibility (in code)
ww	Present weather (in code)
W	Past weather (in code)
PPP	Sea-level pressure (tens, units, tenths) millibars (mb).
TT	Temperature of the air (whole degrees Centigrade)
N <sub>h</sub>	Fraction of celestial dome covered C <sub>L</sub> or C <sub>M</sub> cloud
C <sub>L</sub>	Clouds of types stratocumulus, stratus, cumulus, cumulonimbus (in code)
h	Height of base of lowest C <sub>L</sub> or C <sub>M</sub> cloud above sea
C <sub>M</sub>	Clouds of types altocumulus, altostratus, nimbostratus (in code)
C <sub>H</sub>	Clouds of types cirrus, cirrostratus, cirrocumulus (in code)
D <sub>s</sub>	Ship's course (in code)
v <sub>s</sub>	Speed of ship in knots (in code)
a	Characteristic of barometric tendency (in code)
pp	Amount of barometric change (units and tenths) millibars (mb.)
O	Group designator
T <sub>s</sub> T <sub>s</sub>	Difference between air and sea temperature (half degrees Centigrade)
T <sub>d</sub> T <sub>d</sub>	Temperature of dew point (whole degrees Centigrade)
l	Group designator
d <sub>w</sub> d <sub>w</sub>	Direction from which waves are coming (tens of degrees)
P <sub>w</sub>	Period of waves (in code)
H <sub>w</sub>	Mean height of waves (in code)
ICE	Group designator for ice group
c <sub>2</sub>	Description of kind of ice (in code)
K	Effect of ice on navigation (in code)
D <sub>i</sub>	Bearing of ice limit (in code)
r	Distance of ice from ship (in code)
e	Orientation of ice field (in code)

<sup>1</sup> Adapted from U.S. Weather Bureau Manual of Marine Meteorological Observations, Circular M (11th ed.), January 1963, p. 8.



Errors introduced into the weather message for various reasons are often difficult to note unless they are of serious nature. Data screening at the BCF Biological Laboratory in San Diego is designed primarily to detect the following errors:

1. Departures from major 5-digit groupings: e.g., teletype garbles, run-on groups of 5 or more digits not separated by a space, failure to shift from lower to upper case, and vice versa.

2. Major coding errors in barometric pressure readings: all coded messages are interpreted for values between 950.1 and 1049.9 mb.; coded values greater than 500 are assigned to the range 950.1-999.9 mb., and values less than 500 are assigned to the range 1000.0-1049.9 mb. Observed barometric pressures will be refined further in the future when monthly barometric averages and associated statistics become available for screening purposes.

3. Major errors in sea temperatures: sea temperature observations are screened by comparison with a table of values interpolated from monthly means for the north Pacific Ocean found in the "Atlas of Climatic Charts of the Oceans," U.S. Weather Bureau. Temperatures outside a selected range are rejected and placed in a summary listing for inspection by the analyst.

## DISTRIBUTION OF OBSERVATIONS

Because the data used are compiled primarily from merchant marine weather reports, the distribution of observations over the ocean is irregular. Observations are most numerous in the major shipping lanes from San Francisco to Hawaii, San Francisco to Japan, Panama to San Diego, Los Angeles and San Francisco, and from Seattle to Japan. Shipping lanes of secondary importance are from San Diego to Hawaii, Panama to Hawaii, and Panama south to the ports off the west coast of South America. Vast regions of the equatorial zone and south Pacific Ocean have much less merchant vessel traffic than the north Pacific and, consequently, fewer reports are received from these areas. Sample distributions of the number of usable sea temperature observations are given in figures 1 and 2.

In recent years, progress has been made in obtaining coverage from some regions that heretofore have yielded few reports. One quite important region that has been little covered is the area off the west coast of South America. The importance of this area can be appreciated by examining the world fishing statistics.

In 1961, FAO reported that Peru was surpassed only by Japan in world production of fish and fish byproducts. Recently, WMO has asked that cooperating ships steaming in the area south of the equator and from the west coast of South America to long. 140° W. send reports to "Observer San Francisco." Furthermore, the U.S. Weather Bureau has recently established a Port Visitation Office in Panama and is encouraging vessels passing through the canal into the Pacific to send reports to designated receiving agencies.

## AUTOMATIC DATA PROCESSING OF WEATHER REPORTS

### The Program

Incoming data are received from the U.S. Weather Bureau, San Francisco International Airport, San Bruno, Calif., via the landline teletype circuit, Service "O", Circuit 8274, mentioned previously. Each transmission is converted to a 5-channel paper tape by a teletype reperforator receiver. Concurrent with the reperforator operation, the transmission is duplicated on a page printer machine for message verification purposes and as a backup when the reperforator malfunctions.

The perforated tape is fed into an IBM 047 tape-to-card key punch machine to convert each ship's weather observation to standard data card format. These data cards are then accumulated each month for processing. The data are presorted by octant and longitude into 10-degree wide strips to facilitate processing by the machine and to provide a logical output format. The information on each of the sorted cards is then loaded onto magnetic tape for high-speed input to the computer. The basic steps are schematized in figure 3.

The program in current use is written in FORTRAN-62 source language for the Control Data Corporation 1604 computer located at the University of California, San Diego. A machine language deck has been prepared from the source language statements for routine processing of synoptic data. The computer program processes the cards and prepares output summaries for each 10-degree strip of longitude separately until all accumulated cards are processed. Data cards are summarized at the rate of 5 per second and the output tape is produced at the rate of 40 lines per second. The output tape is subsequently listed on multicopy paper for tabulation assembly. The flow charts in figures 4-6 depict the major data processing functions performed; numerical designators are keyed to processing statements within the program listing in Appendix A.

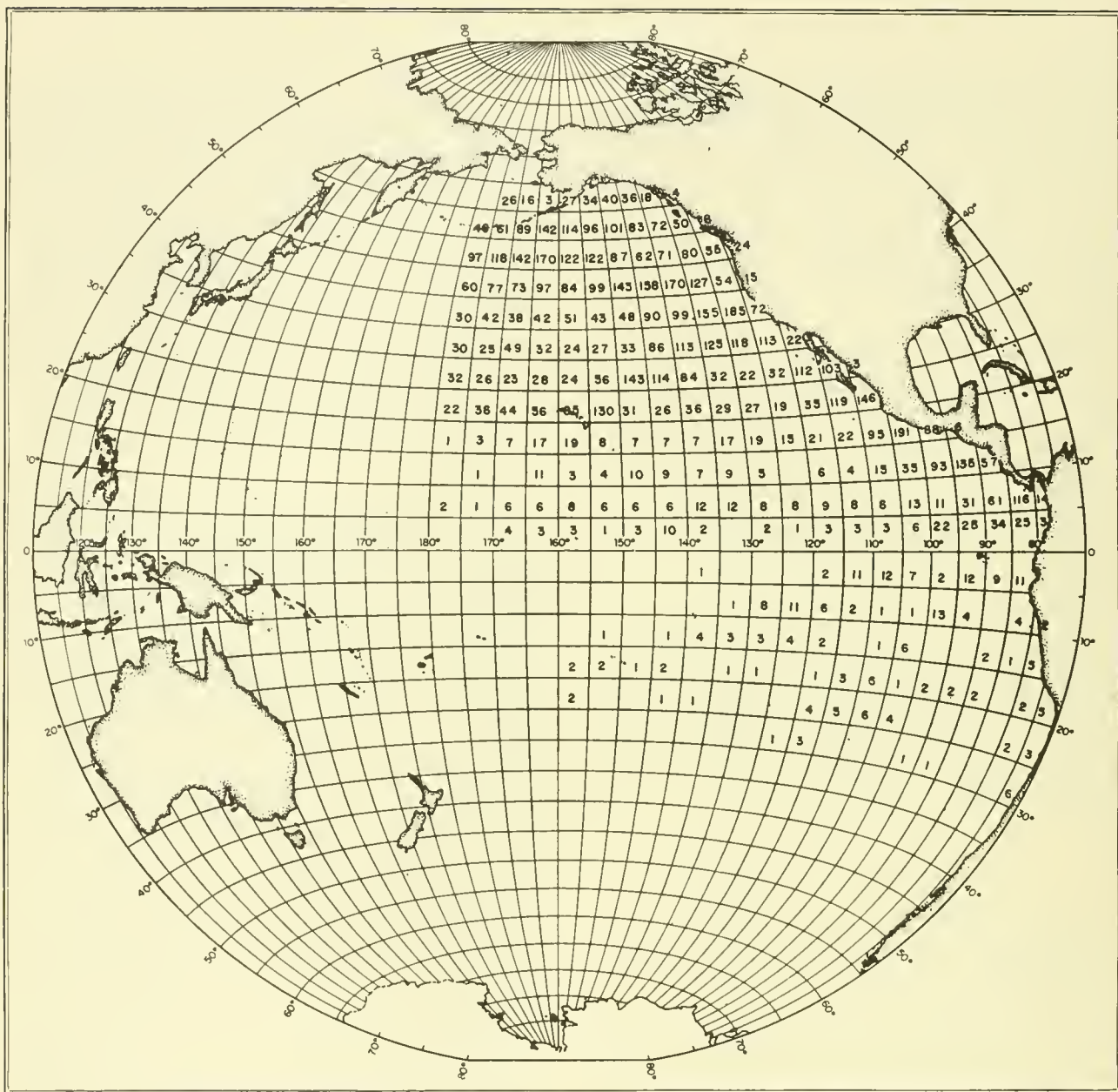


Figure 1.--Distribution of screened sea temperature observations derived from the synoptic marine weather observations, August 1963.

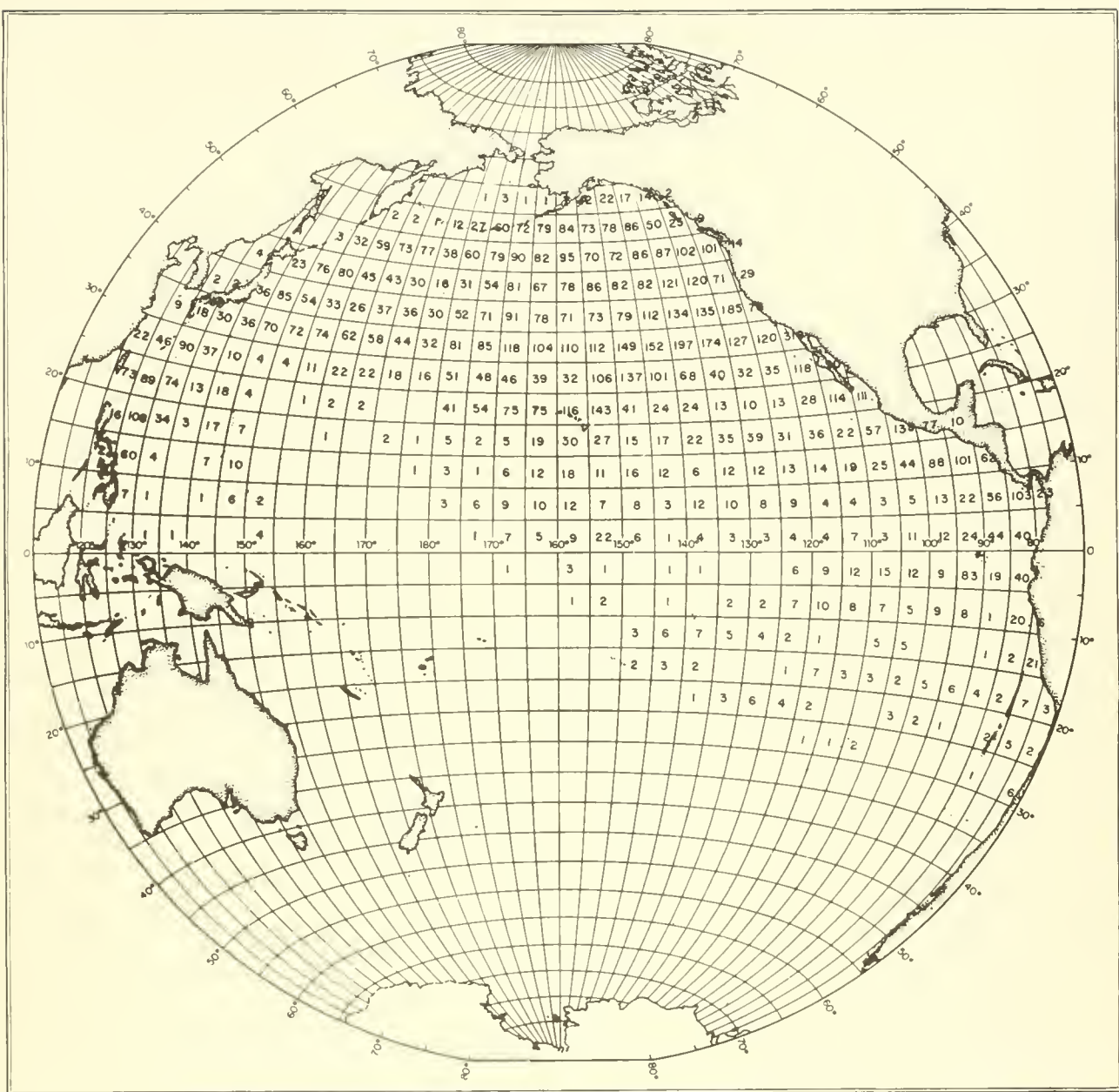


Figure 2.--Distribution of screened sea temperature observations derived from the synoptic marine weather observations, February 1964.

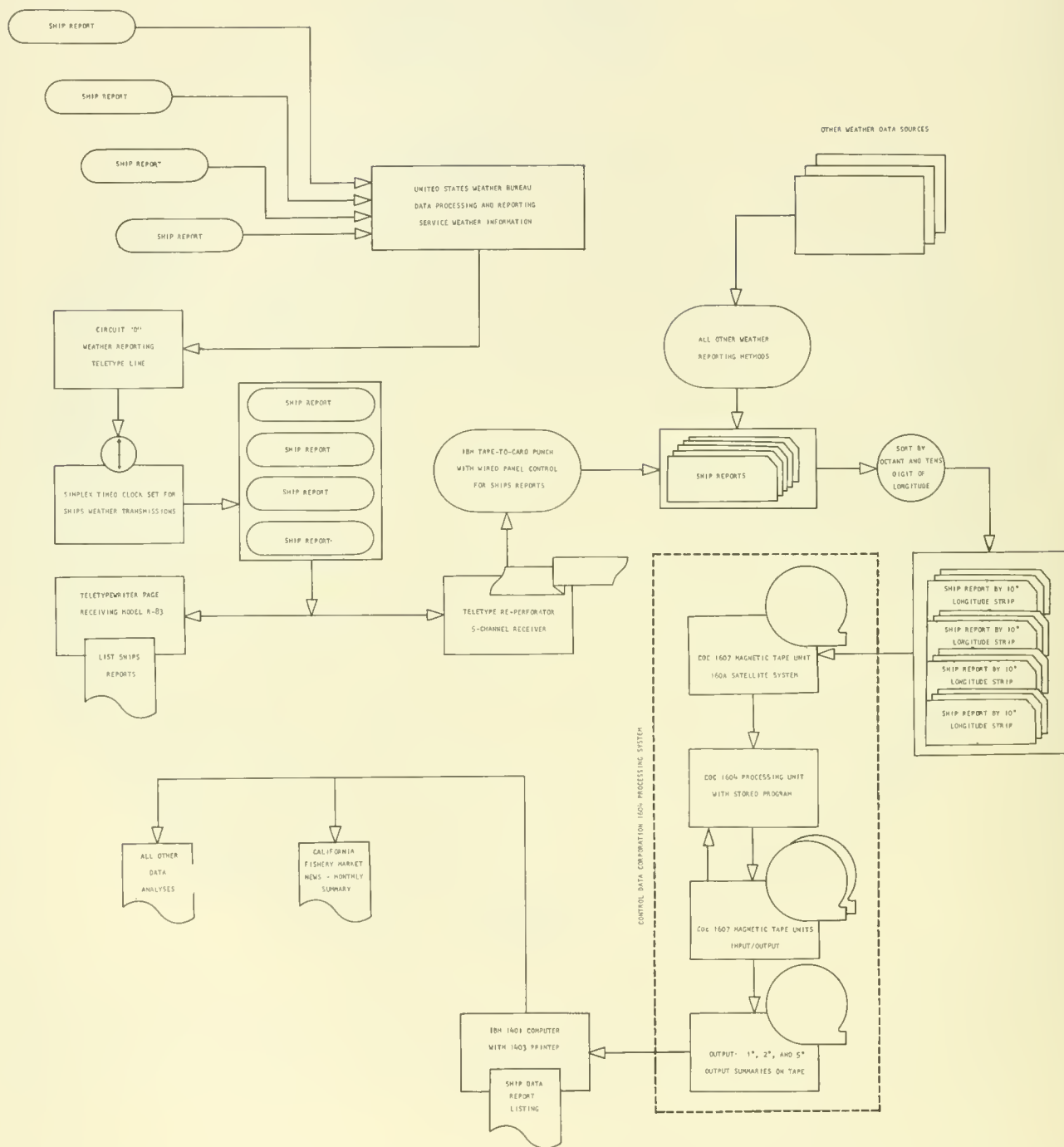
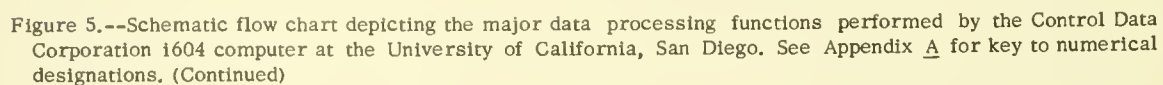


Figure 3.--Schematic diagram of the automatic weather data processing system in use by the Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.









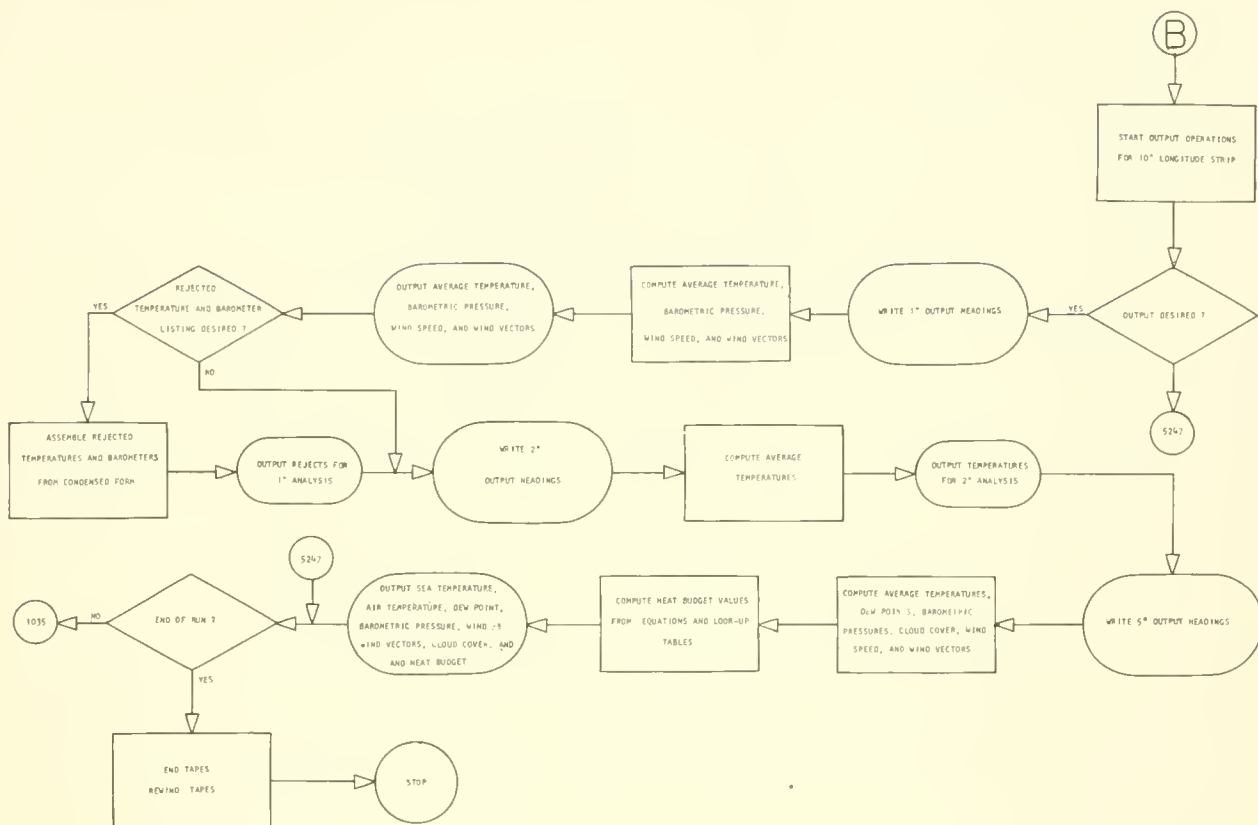


Figure 6.--Schematic flow chart depicting the major data processing functions performed by the Control Data Corporation 1604 computer at the University of California, San Diego. See Appendix A for key to numerical designations. (Continued)

## Monthly Data Readout

It is becoming increasingly clear to marine scientists that much interaction occurs between the ocean and the atmosphere (Eber and Sette, 1959; Hanzawa, 1962; Namias, 1963; Uda, 1960, 1962). To provide data for research into air-sea interaction studies, not only sea surface temperatures but also other variables contained in the marine synoptic weather report are summarized. The basic elements of the monthly data compilations are listed in four major tables, as follows<sup>1</sup>:

**Table 1.001-1.069--Sea surface temperatures (° F.) with number of observations by 1-degree quadrangles for the month of [entry changes each month].**

**Table 2.001-2.184--Barometric pressures (mb.), X- and Y-wind vectors (knots), and average wind speed (knots) with number of observations by 1-degree quadrangles for the month of [same as above].**

<sup>1</sup>For convenience in output assembly, pages within each table are numbered consecutively from .001.

**Table 3.001-3.046--Sea surface temperatures (° F. and C.) and number of observations by 2-degree quadrangles for the month of [same as above].**

**Table 4.001-4.069--Sea surface temperatures (° C.), air temperatures (° C.), dew point temperatures (° C.), barometric pressures (mb.), X- and Y-wind vectors (knots), average wind speeds (knots), cloud cover (tenths of sky covered), and heat budget (calories per square centimeter per day), with number of observations by 5-degree quadrangles for the month of [same as above].**

Sample page copy of each table listed above is included in Appendix C. Each table conforms to the following conventions:

1. **Latitude and longitude range headings--**Identify a 10-degree wide strip of longitude and give its length in latitude. Each successive page with identical range headings belongs in the same 10-degree strip.

2. **Latitude and longitude indices--**Give map location of each piece of data. Answer is

assumed to be for the geometric center of each quadrangle. Location given on output is actually the corner of the quadrangle and follows this convention:

- Octants 0, 1 - lower right corner
- Octants 2, 3 - lower left corner
- Octants 5, 6 - upper right corner
- Octants 7, 8 - upper left corner

(Where octant designations conform to Hydrographic Office Publication No. 206 code form FM 21.A. "Surface Report From Ship in Full Form.")

3. Wind vectors--Wind vectors follow this convention:

- (a) X--vectors run due east and west  
East--positive  
West--negative
- (b) Y--vectors run due north and south  
North--positive  
South--negative

4. Average wind speed--The simple average of all observations irrespective of direction (Note - does not necessarily equal  $\sqrt{X^2 + Y^2}$ ).

5. Heat budget computations--The net energy exchange at the air-sea interface. The printout has the following sign convention:

- (a) Energy into sea--positive
- (b) Energy out of sea--negative

The computer printout labels of various components of the equation are:

- Q(T) - total (net) energy exchange across air-sea interface)
- Q(I) - incoming solar radiation corrected for cloud cover
- Q(R) - radiation reflected by sea surface
- Q(B) - back radiation
- Q(E) - heat loss or gain through evaporation or condensation

Q(H) - sensible heat conduction between sea and air

Energy exchange equations will be discussed in subsequent sections of this paper.

The following notes are given to clarify some aspects of the data:

1. A blank in heat budget output [Q(T), Q(I), Q(R), Q(B), Q(E), Q(H)] is equal to 0.

2. When any heat budget value [Q(T), Q(I), Q(R), Q(B), Q(E), Q(H)] is between -1 and 0, a minus sign only appears as entry.

3. Any entry or a blank followed by (0) means no data for that quadrangle.

CHARTS DERIVED FROM  
MONTHLY READOUT

Sea Surface Temperature Charts

Examples of monthly sea surface temperature charts obtained by using the data summaries and reported in the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information are shown in figures 7-12. Figure 7 depicts the monthly sea surface isotherm configuration derived from ships' weather reports, average sea temperatures at Weather Ship Stations November and Papa, and average temperatures of coastal stations. Because coastal station data are mailed and must reach the BCF San Diego Laboratory by the first day after the close of a month for processing, the coastal station averages, except for that reported at the pier of Scripps Institution of Oceanography, usually represent only about the first 25 days of each month. Coastal stations included in figure 7 are as follows:

Station	Location	
	Latitude	Longitude
Langara Island -----	54°15' N.	133°03' W.
Cape St. James -----	51°56' N.	131°01' W.
Quatsino Island -----	50°27' N.	128°02' W.
Amphitrite Point -----	48°55' N.	125°32' W.
Umatilla Lightship -----	48°10' N.	124°50' W.
Columbia River Lightship -----	46°11' N.	124°11' W.
Blunt's Reef Lightship -----	40°26' N.	124°30' W.
Russian Gulch State Park -----	39°18' N.	123°48' W.
Sonoma Coast State Park -----	38°23' N.	123°05' W.
Farallon Island Lightship -----	37°46' N.	122°42' W.
Hopkins Marine Station -----	36°38' N.	121°55' W.
Gaviota State Park -----	34°28' N.	120°14' W.
Santa Barbara -----	34°24' N.	119°42' W.
Doheny State Park -----	33°28' N.	117°41' W.
Scripps Institution of Oceanography--	32°52' N.	117°15' W.
Ensenada -----	31°52' N.	116°38' W.
Guadalupe Island -----	28°41' N.	118°17' W.
Cedros Island -----	28°15' N.	115°10' W.

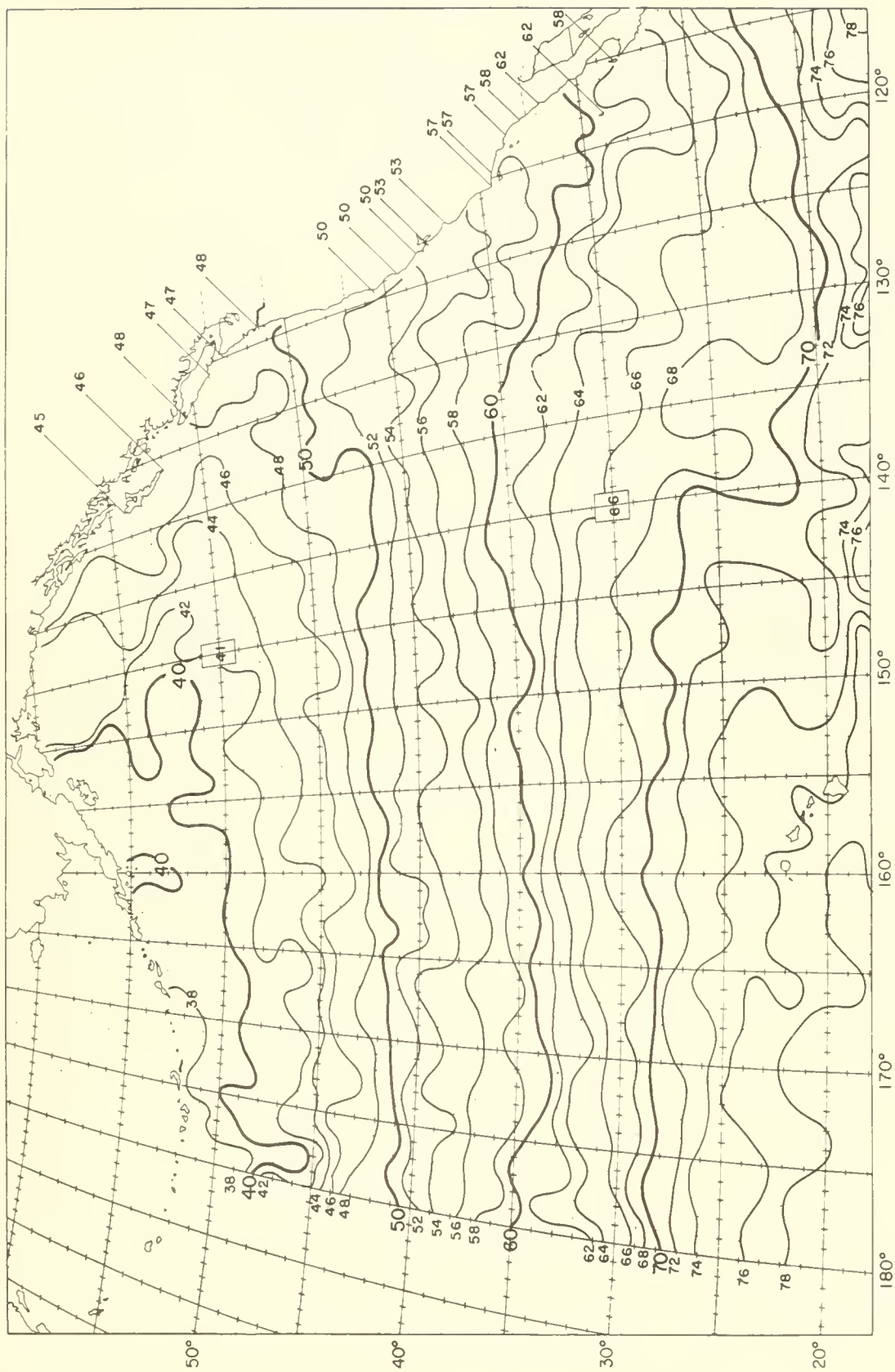


Figure 7.--Mean sea surface temperatures ( $^{\circ}$  F.), February 1-29, 1964.

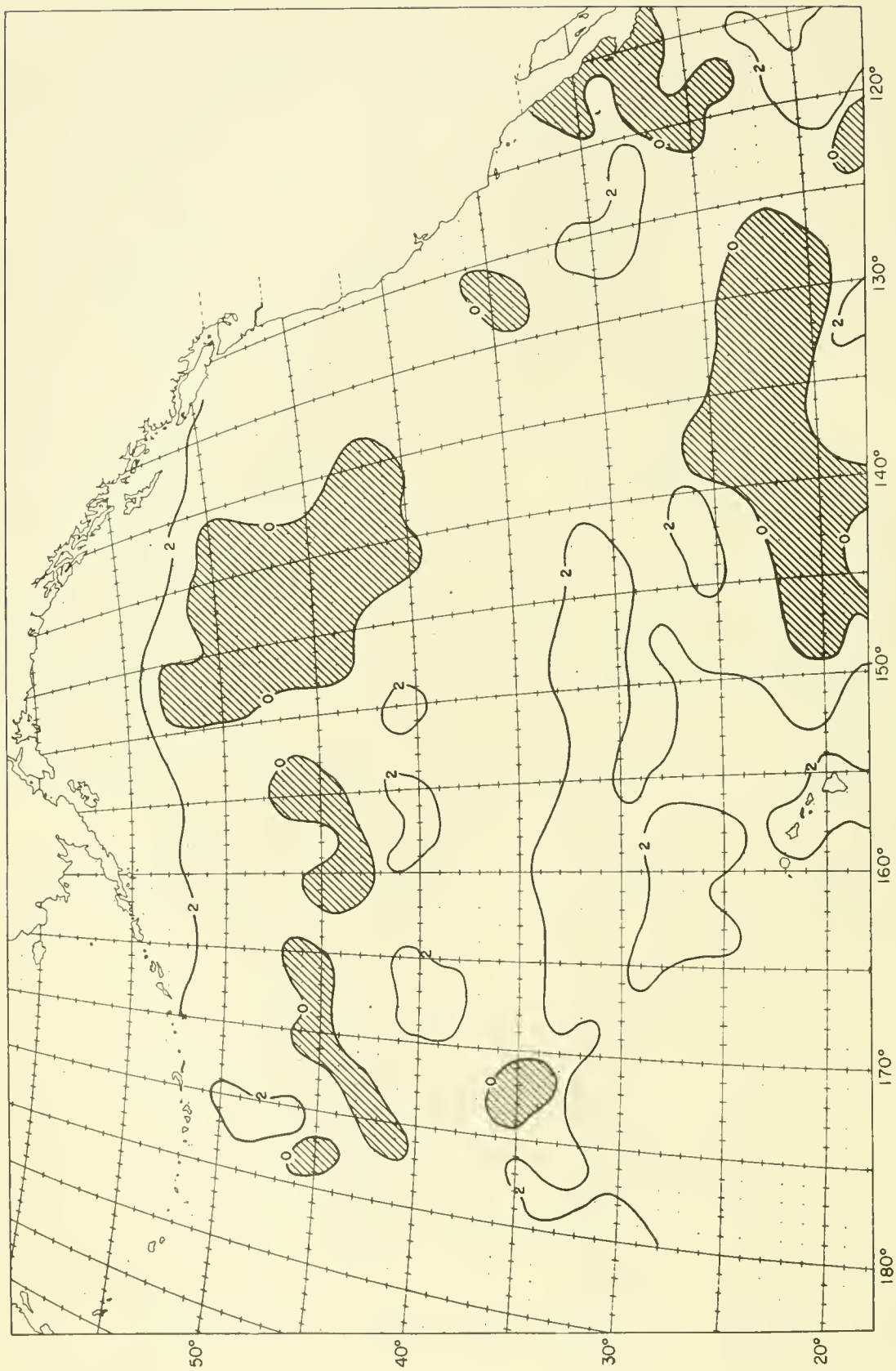


Figure 8. -- Deviation of sea surface temperatures ( $^{\circ}$  F.) from long-term mean, February 1964. Hatched areas colder in 1964.



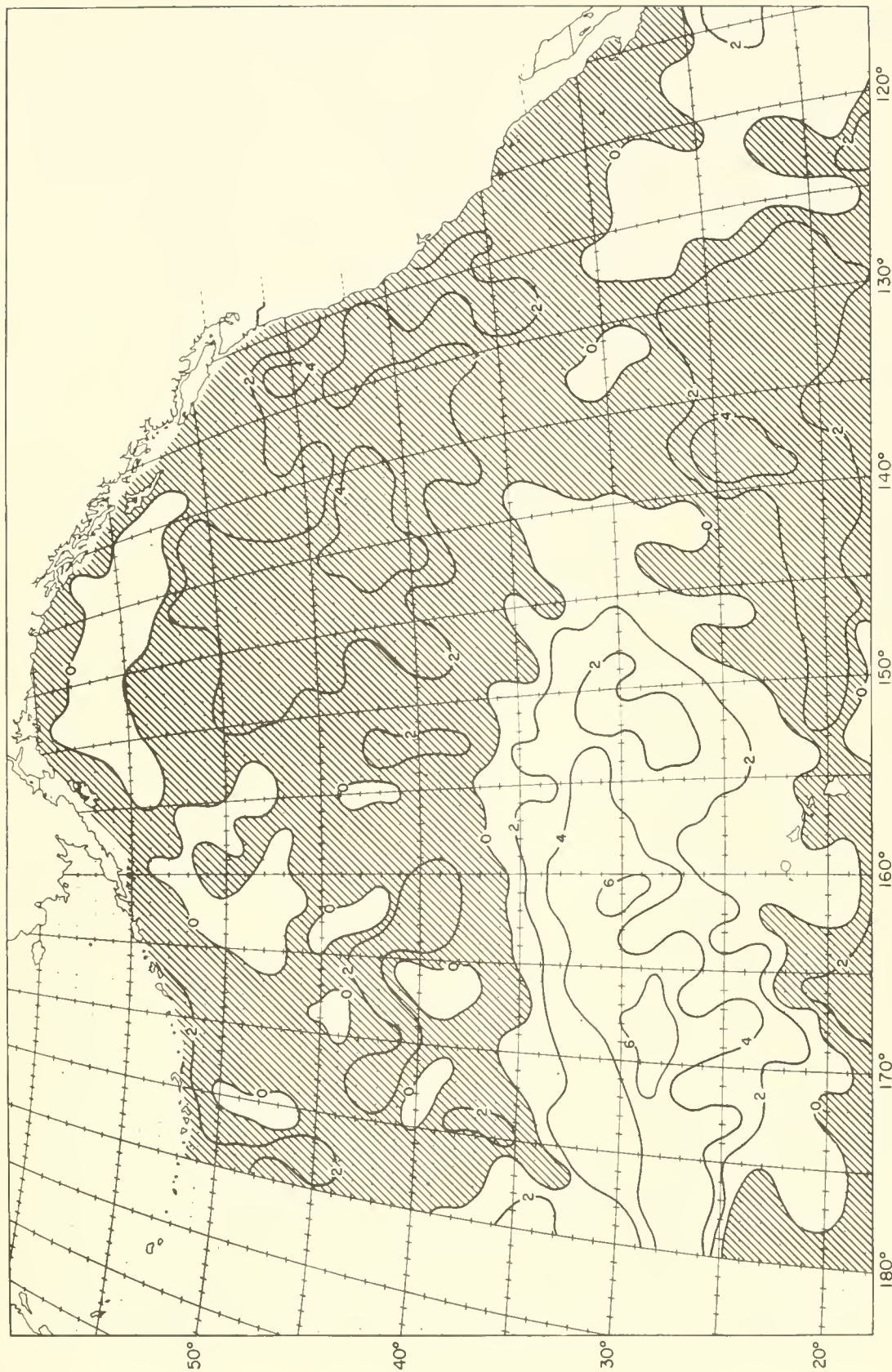


Figure 9.---Deviation of sea surface temperatures ( $^{\circ}$  F.) from February 1963 - February 1964. Hatched areas colder in 1964.



Figure 10.--Sea surface temperatures by 1-degree quadrangles, February 1-29, 1964. Temperatures underlined indicate average of two or more observations.







Monthly sea surface temperature deviations for February 1964, from the long-term mean charts given in H.O. 225, World Atlas of Sea Surface Temperatures, 2d ed., 1944, appear in figure 8. The exact base period used for construction of the mean charts is not known.<sup>2</sup>

The deviation of sea surface temperature, February 1964, from the corresponding month of the previous year is given in figure 9.

Whereas three of the charts (figs. 7-9) encompass the temperate north Pacific Ocean east of the 180th meridian, the remainder (figs. 10-12) give data for the eastern tropical Pacific Ocean. The first (fig. 10) of these gives actual average temperatures by 1-degree quadrangles; underscored values represent averages from two or more observations. The next chart (fig. 11) gives the deviation from the previous year by 1-degree quadrangles, and the last (fig. 12) shows the deviation by 2-degree blocks from the 12-year (1947-58) mean prepared by Renner (1963). When the 10-year (1950-59) mean is completed by the BCF Biological Laboratory at Stanford, this chart, too, will be based on the same period. Because of the scarcity of observations from the tropical regions, actual values are presented instead of contoured values.

From April through October, as a supplement to the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information, a series of charts covering 15-day intervals is prepared and distributed to albacore fishermen and to others interested in receiving it (fig. 13). This chart covers the region from the coast of North America to long. 136°30' W. and from lat. 25° N. to 52° N. It is designed to span the area and season when the commercial albacore fishery takes place off the Pacific coast.

## Meteorological Charts

Charts are prepared each month from the readout for averages of cloud cover (figs. 14 and 15), wind speed (figs. 16 and 17), air temperature (figs. 18 and 19), dew point temperature (figs. 20 and 21), sea temperature (figs. 22 and 23), and barometric pressure (figs. 24 and 25). Values are summarized by 5-degree quadrangles of latitude and longitude.

<sup>2</sup>The introduction of H.O. 225 states as follows: "This world atlas of sea surface temperatures was prepared by the Scripps Institution of Oceanography, La Jolla, California, from all sea surface temperature information collected by the U.S. Hydrographic Office, together with all available data from other sources, with special reference to regions of few observations. It is believed that this compilation represents the most accurate pattern of sea surface temperatures of the world yet prepared." The staff of the Bureau of Commercial Fisheries Biological Laboratory, Stanford, Calif., is now preparing a 10-year mean for the period 1950-59. When the new mean becomes available, the anomaly chart will be based on it.

Values are not plotted for 5-degree quadrangles having fewer than five observations. Two charts of each of the variables at opposite climatological seasons show the magnitude of seasonal changes occurring over the ocean. Charts for August 1963 cover the Pacific only from the American coasts to long. 180° because it was not until January 1964 that data were programmed to cover the entire Pacific Ocean. These data are distributed monthly on a limited mailing list.

## Energy Exchange Computations and Charts

The marine synoptic weather report contains basic data for computation of the energy exchange occurring at the air-sea interface. The methods described below represent one of the first attempts to monitor the gross energy flux at the air-sea interface over a broad expanse of the ocean on a monthly basis.

For a given area and time period, the equation for the energy exchange at the air-sea interface is  $Q_T = Q_I - Q_R - Q_B - Q_E - Q_H$ . (See page 10 for definitions of elements of this equation.) The gain or loss of heat, added to that resulting from horizontal and vertical advection, represents the total heat energy available to the upper mixed layer of the ocean. Energy exchange calculations presented here do not take into account changes in heat brought about by advection.

Energy exchange equations have been reviewed in detail by Sverdrup, Johnson, and Fleming (1942), Jacobs (1951), Roden (1959), Laevastu (1960), and others. Opinion differs considerably as to the accuracy of the various equations describing the total energy exchange at the air-sea interface. It is not the intent here to review the accuracy of the many different equations that have been proposed. Controlled experiments similar to those carried out on Lake Hefner by Anderson (1954) and Marciano and Harbeck (1954) are needed to determine which of the equations most closely describes what actually takes place in the ocean.

$Q_I$ , incoming solar radiation corrected for cloud cover (in cal./cm.<sup>2</sup>/day), is determined from the following equation proposed by Berliand (1960):

$$Q_I = (\text{Berliand table})^3 \times (1 - aC - bC^2)$$

where  $C$  = cloudiness in tenths

$$\frac{b}{a} = 0.38$$

and  $\frac{a}{a}$  = a function of latitude as follows:

Latitude:	0	5	10	15	20	25
$\frac{a}{a}$	0.38	0.40	0.40	0.39	0.37	0.35
Latitude:	30	35	40	45	50	55
$\frac{a}{a}$	0.36	0.38	0.38	0.38	0.40	0.41

<sup>3</sup>See Appendix table B-1 for Berliand's table which lists values of incoming solar radiation with a clear sky.



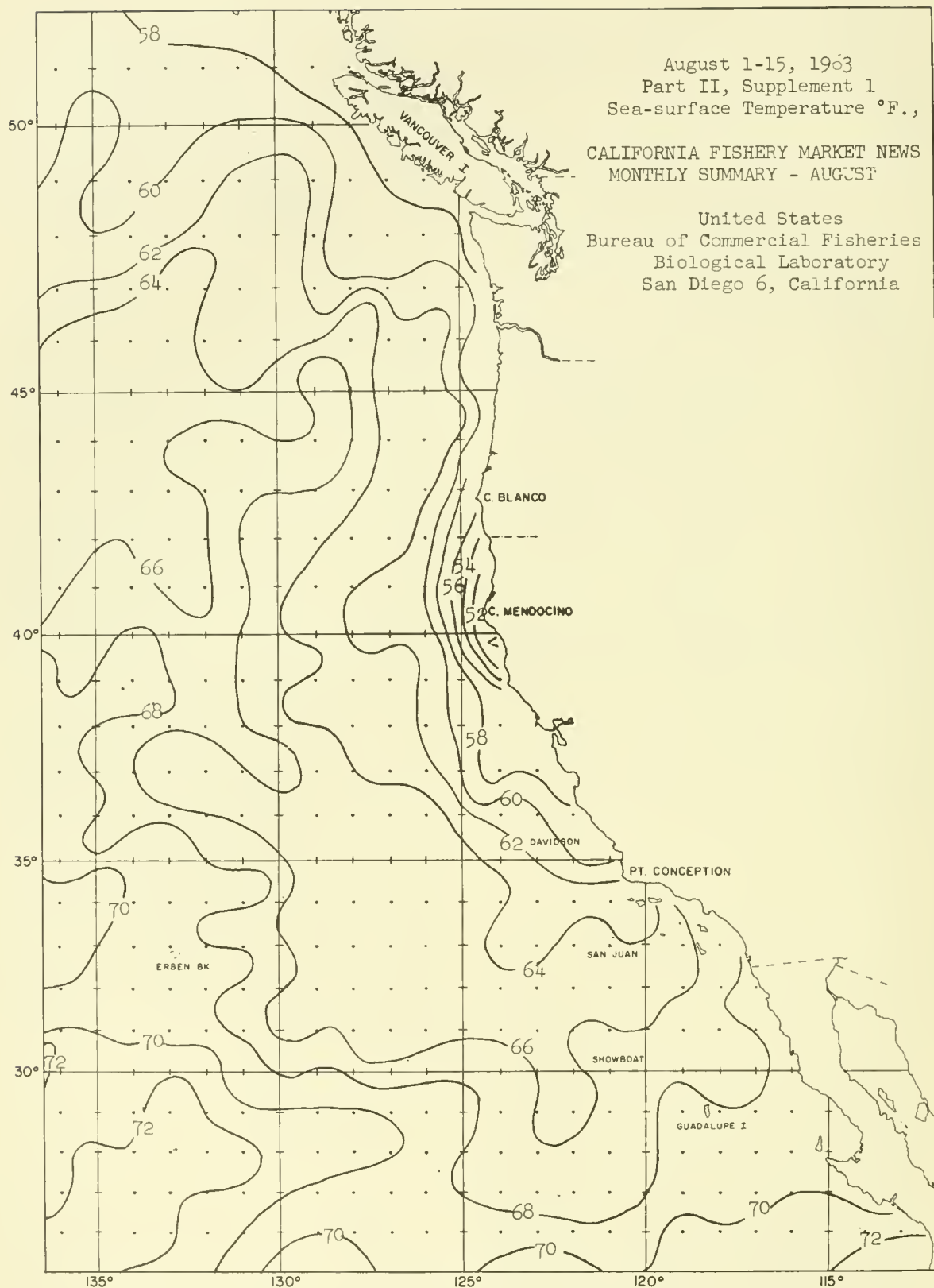


Figure 13.--Sea surface temperature chart for 15-day period, August 1-15, 1963.

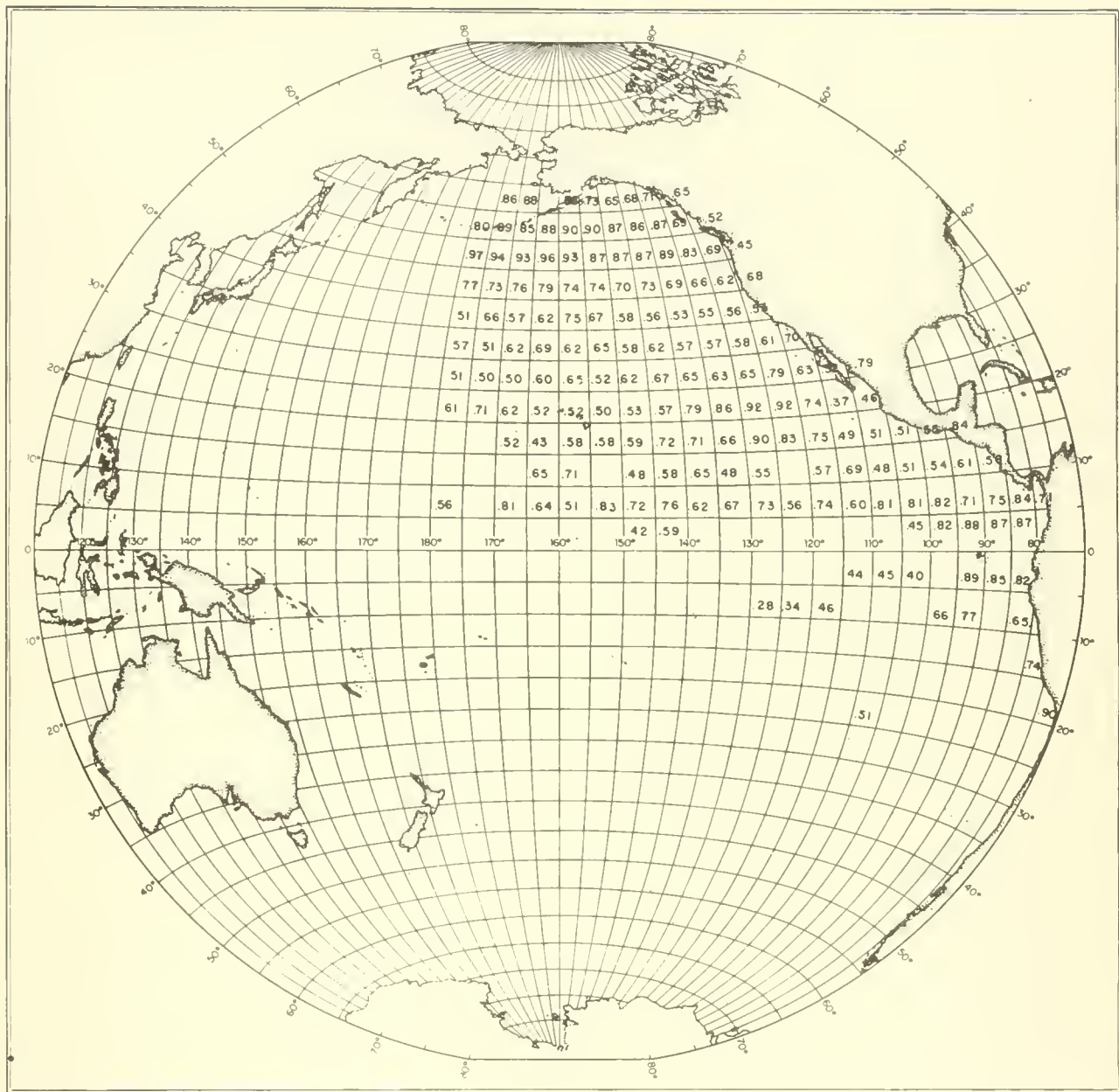


Figure 14.--Cloud cover (hundredths), August 1963.

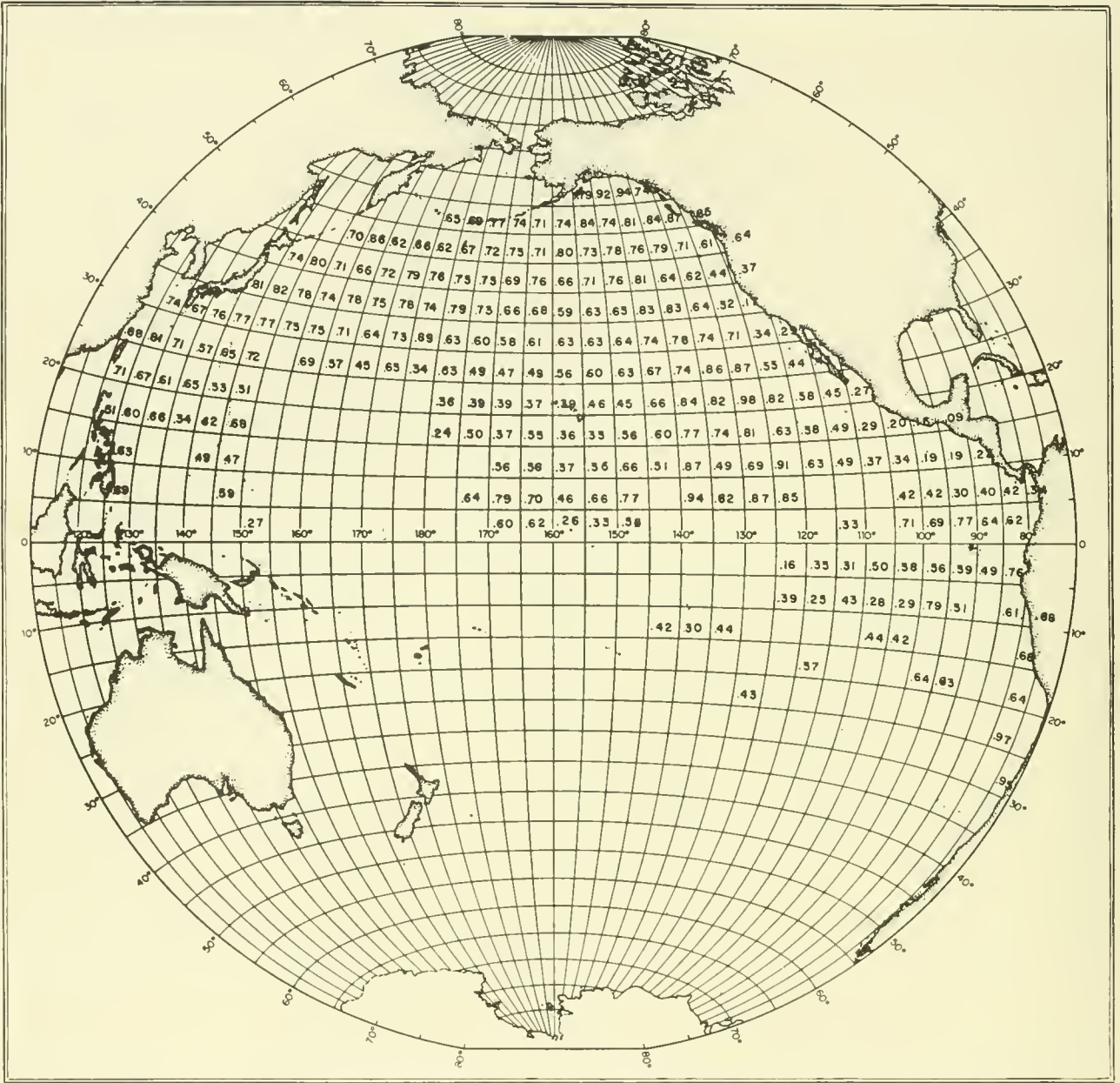


Figure 15.--Cloud cover (hundredths), February 1964.



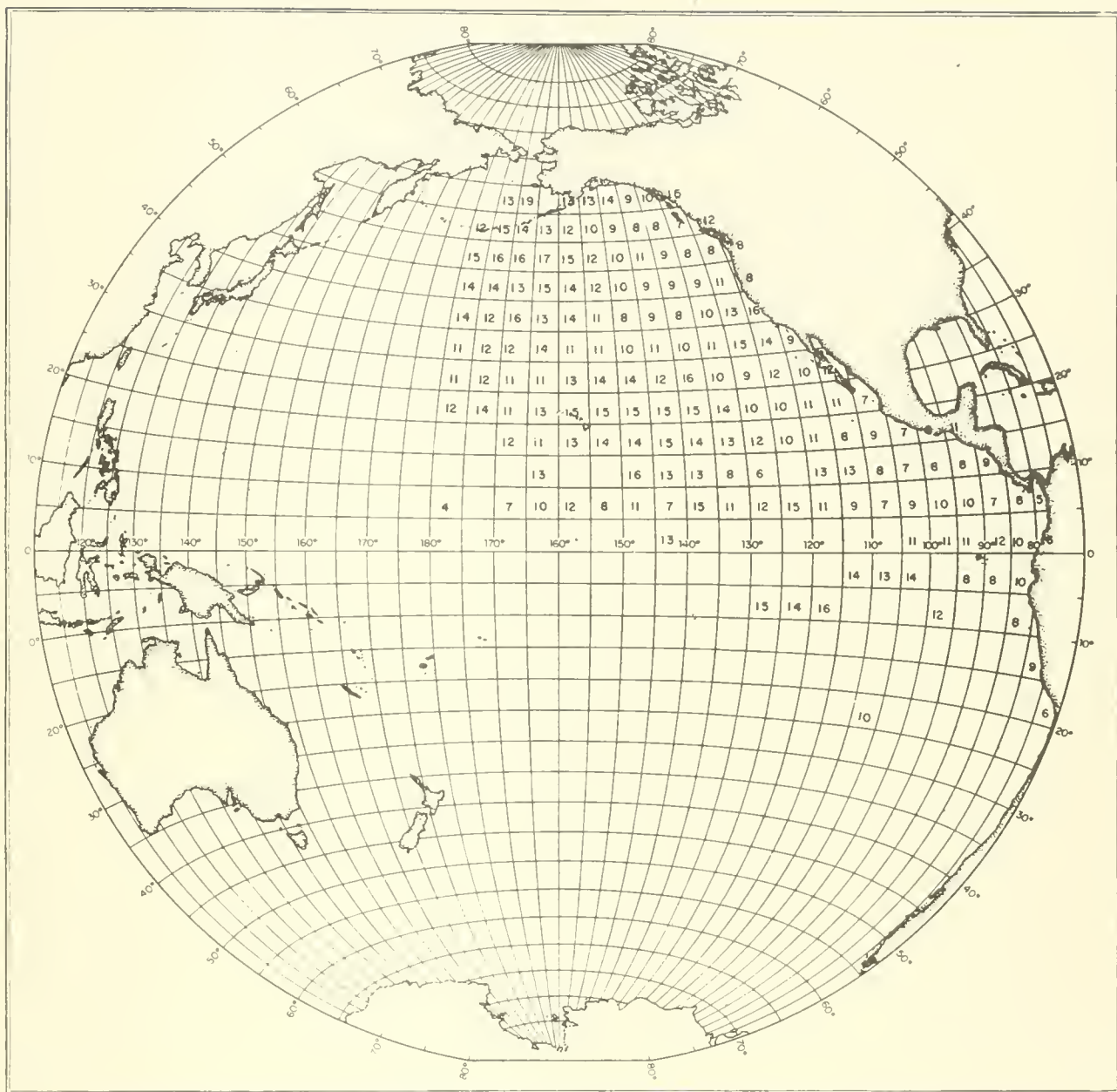


Figure 16.--Wind speed (knots), August 1963.

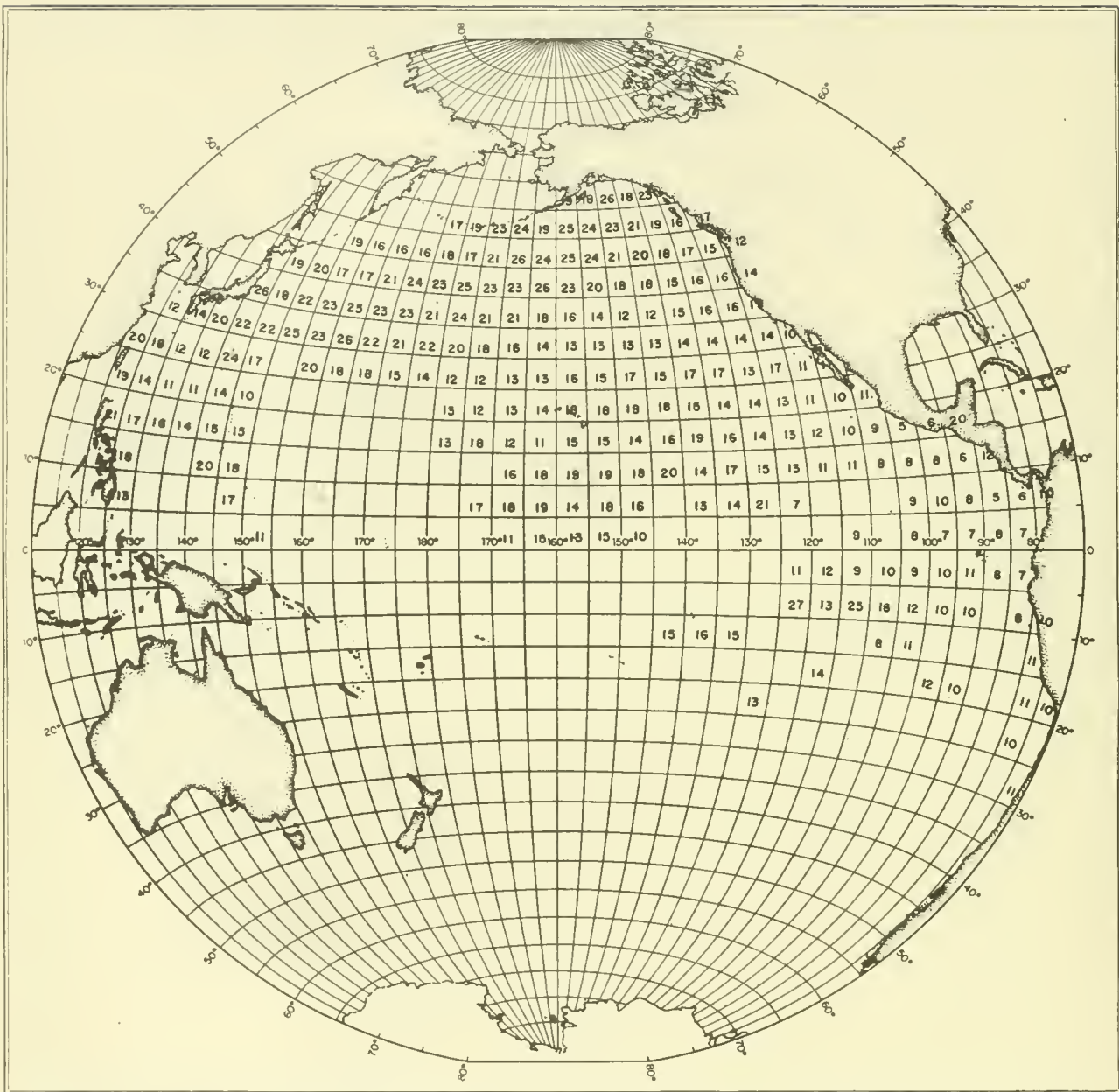


Figure 17.--Wind speed (knots), February 1964.

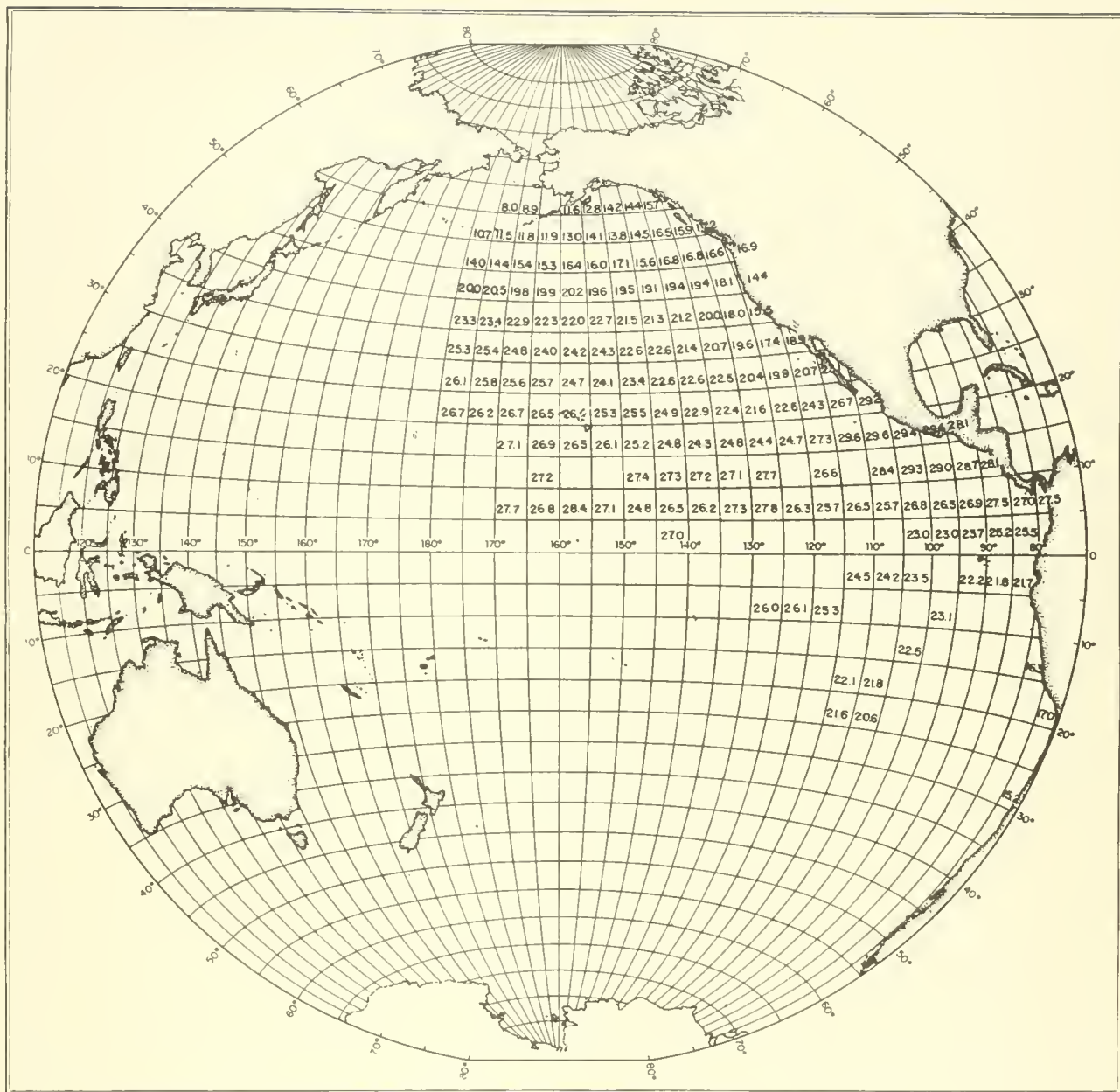


Figure 18.--Air temperature ( $^{\circ}$  C.), August 1963.

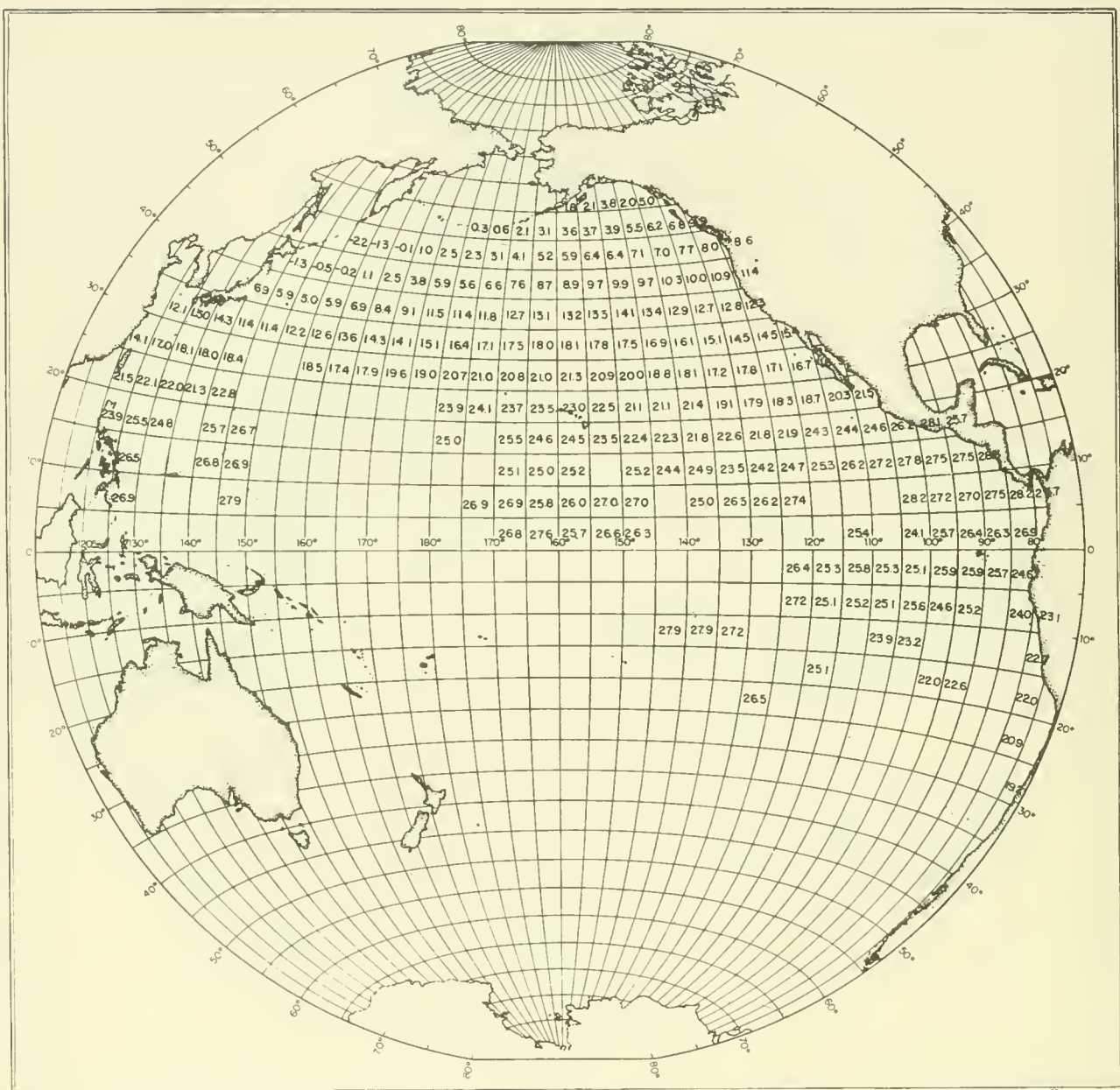


Figure 19.--Air temperature ( $^{\circ}$  C.), February 1964.



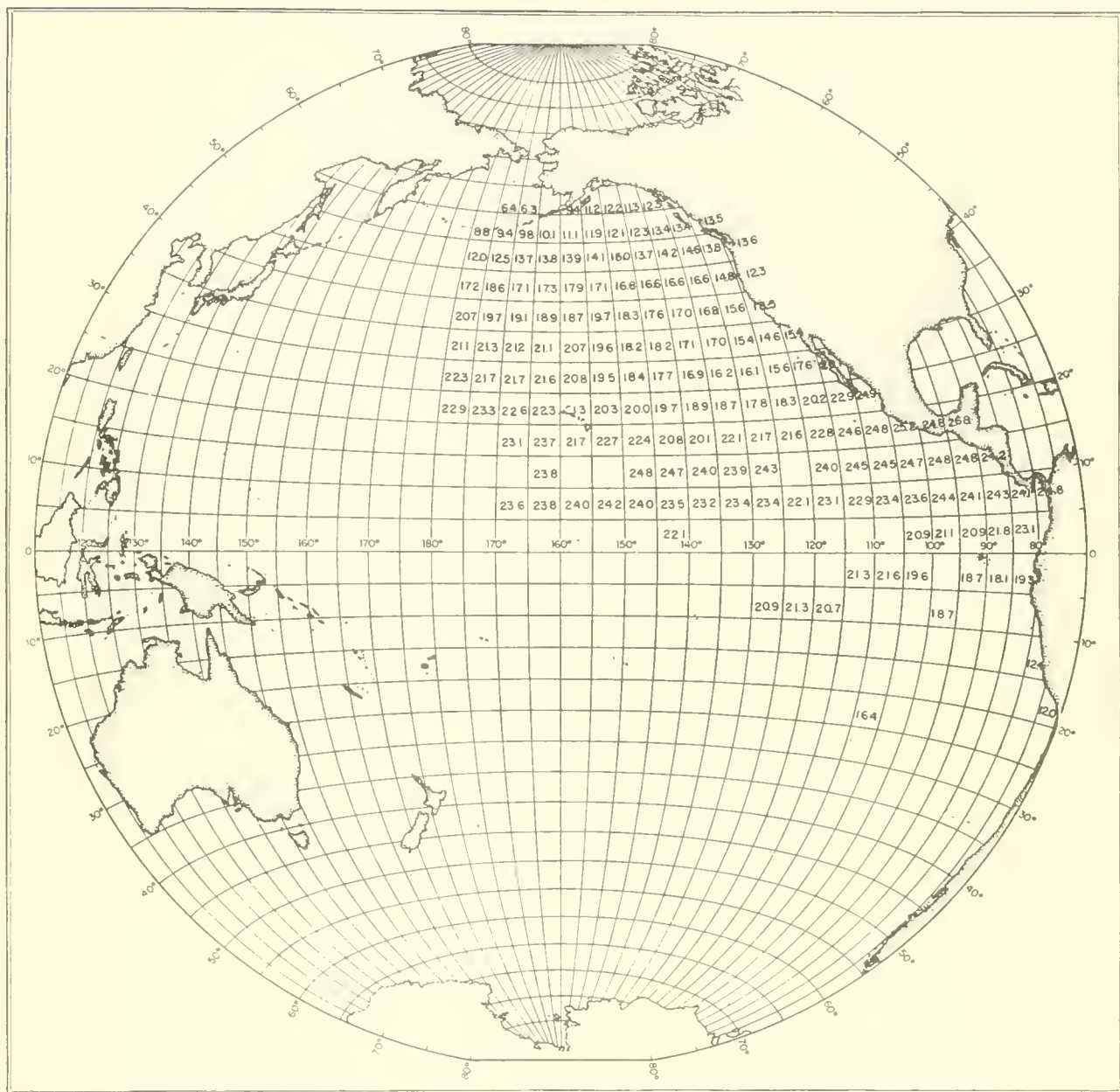


Figure 20.--Dew point temperature ( $^{\circ}$  C.), August 1963.

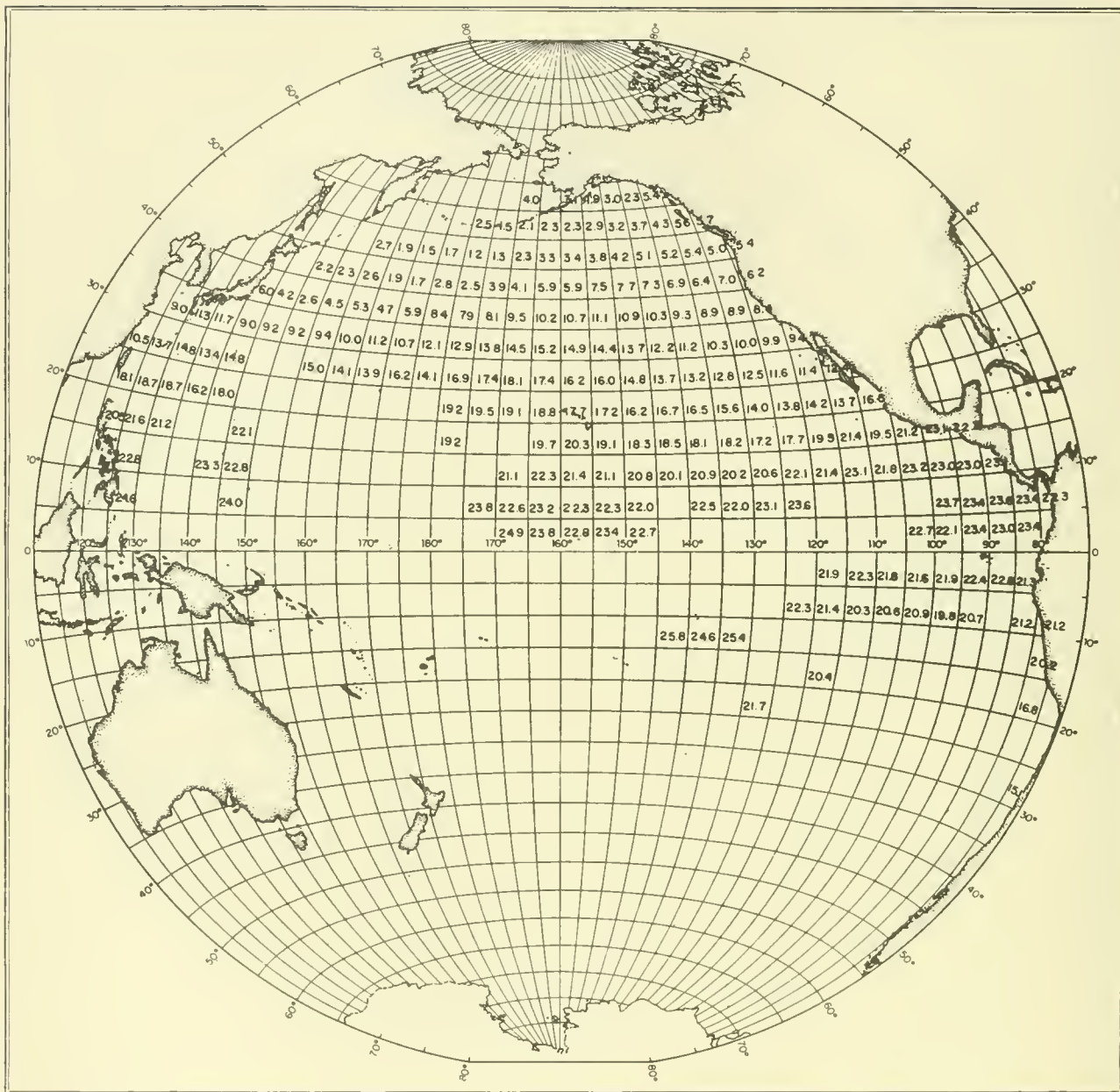


Figure 21.--Dew point temperature ( $^{\circ}$  C.), February 1964.



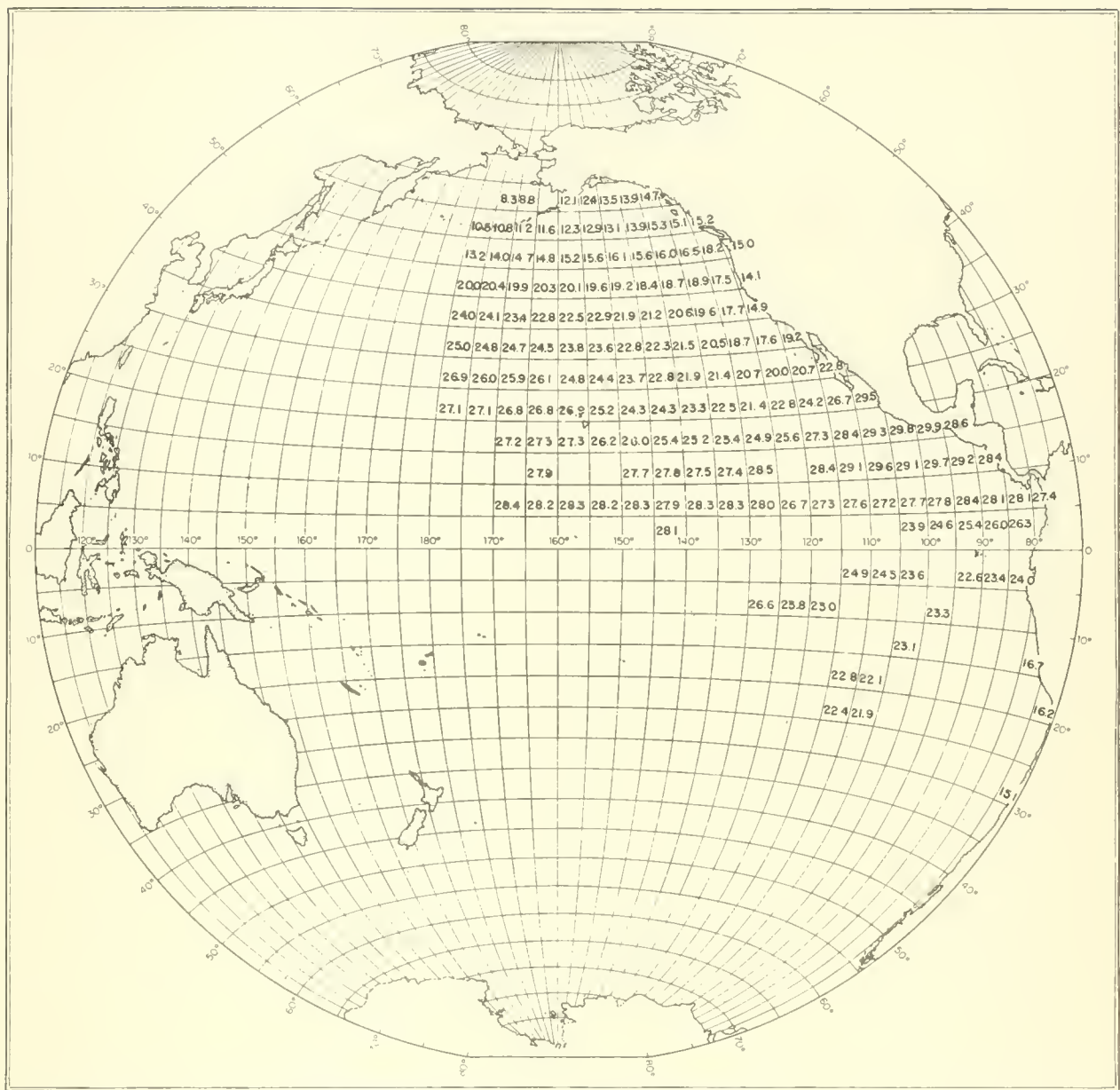


Figure 22.--Sea surface temperature ( $^{\circ}$  C.), August 1963.

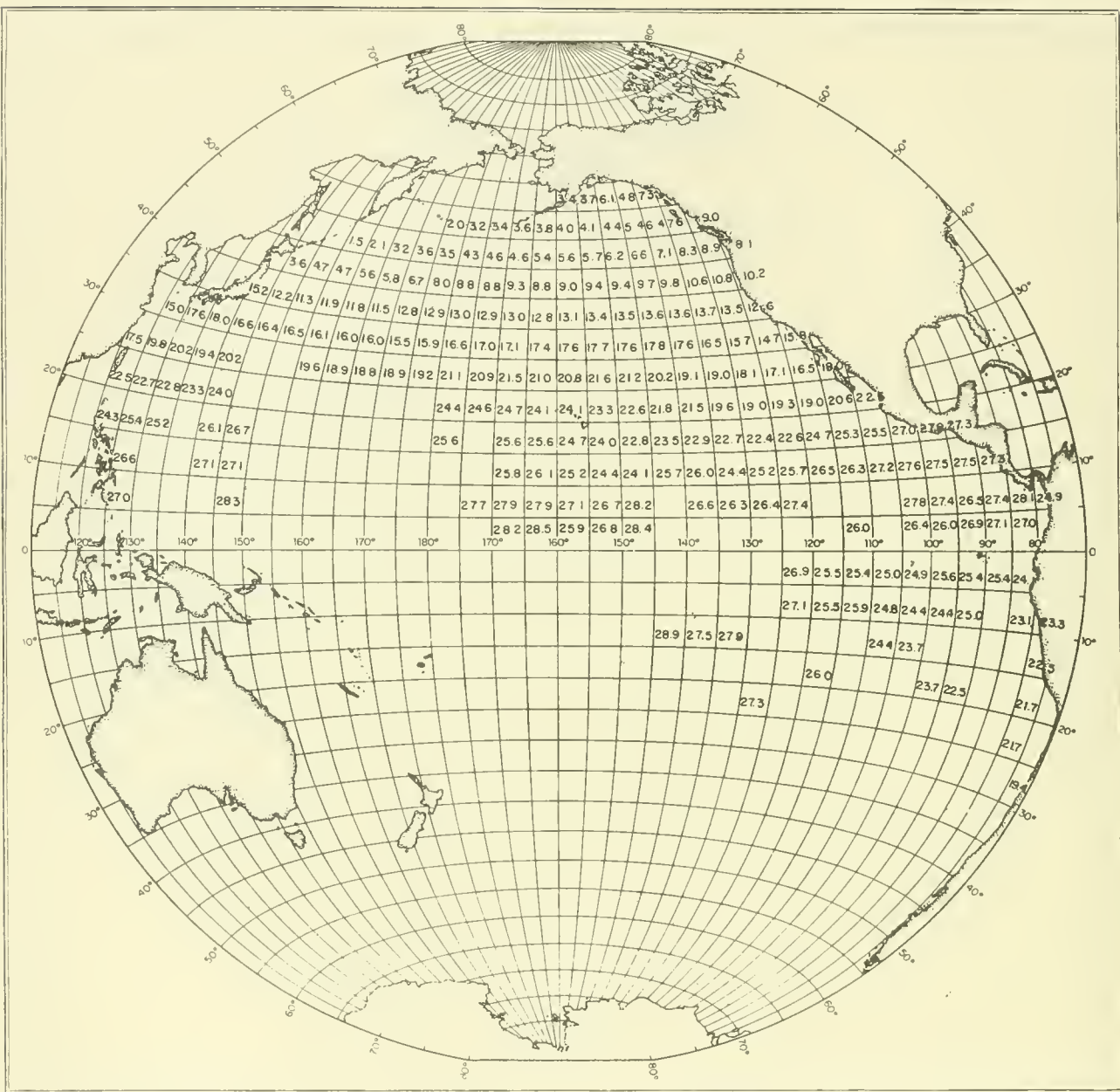


Figure 23.--Sea surface temperature ( $^{\circ}$  C.), February 1964.

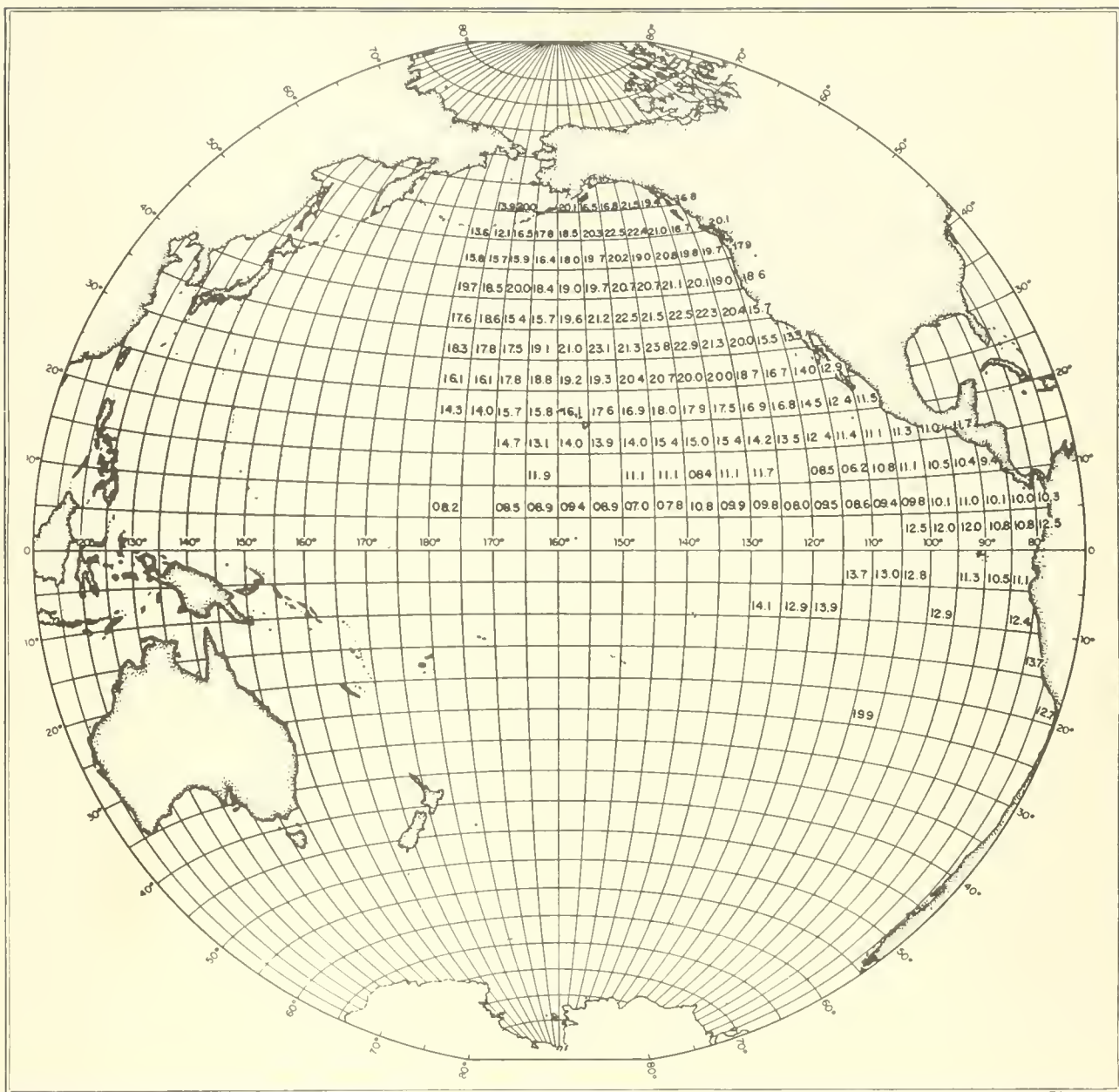


Figure 24.--Barometric pressure (mb.), August 1963.

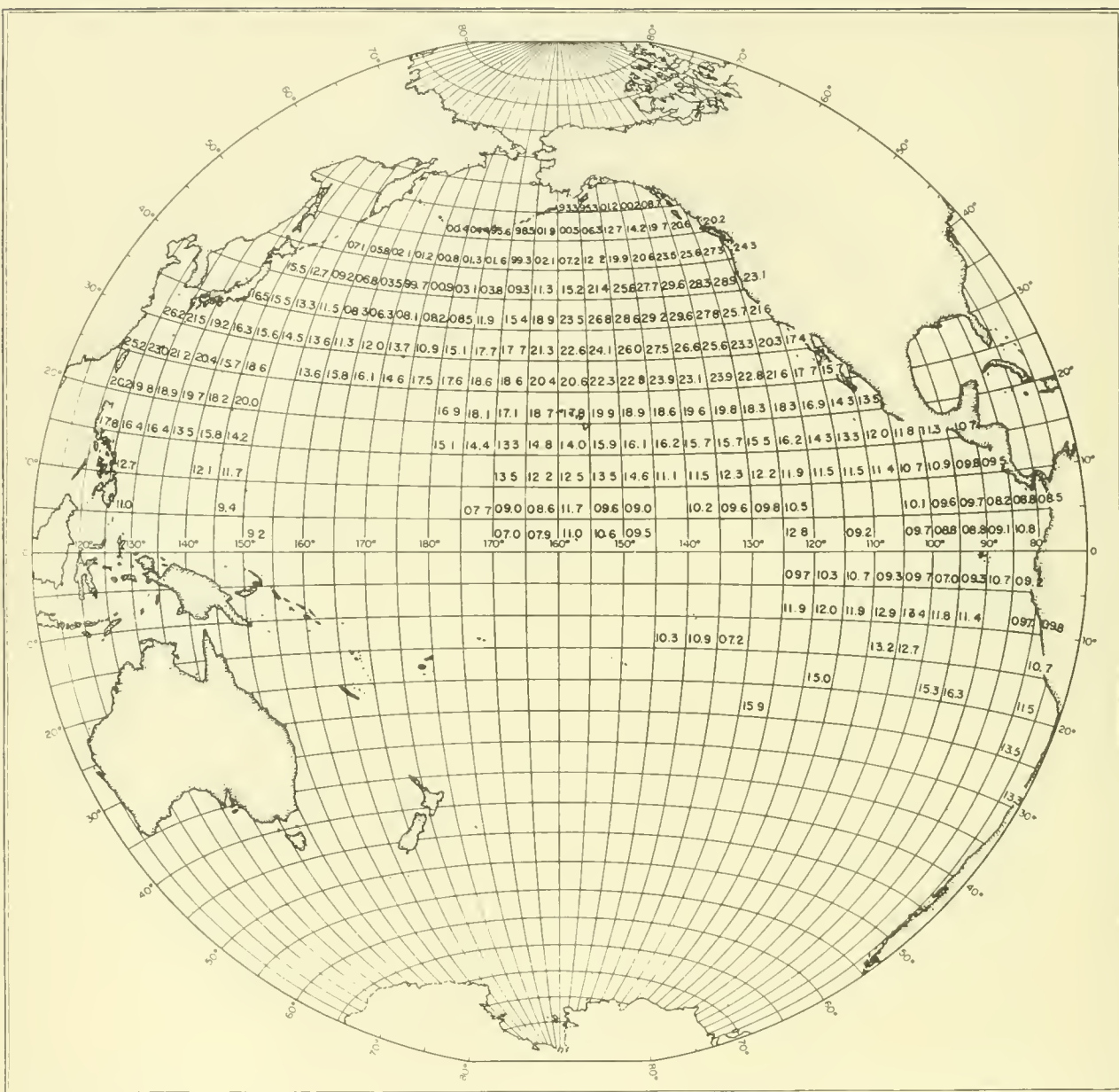


Figure 25.--Barometric pressure (mb.), February 1964.



Of the incoming radiation corrected for the screening effects of cloud cover, some is reflected at the sea surface. The amount reflected depends on the latitude and time of year. The computational expression is as follows:

$$\underline{Q}_R = \underline{Q}_I \times \underline{r}$$

where  $\underline{r}$  = percentage of radiation reflected presented in a table by Budyko (1956); this table is listed in Appendix B-2. The percentage varies from about 6 percent in low latitudes to more than 20 percent in high latitudes in winter.

Back radiation,  $\underline{Q}_B$  (in cal./cm.<sup>2</sup>/day), is the difference between long-wave radiation from the sea surface and long-wave radiation from the atmosphere. The following semi-empirical equation proposed by Berliand and Berliand (1952), and used by Roden (1959) for studies of the California Current system, has been incorporated in this study:

$$\underline{Q}_B = \underline{s} \theta_{\text{sea}}^4 (0.39 - 0.050 \sqrt{\underline{e}}) (1 - \underline{k} \underline{C}^2) + 4 \underline{s} \theta_{\text{sea}}^3 (\theta_{\text{sea}} - \theta_{\text{air}})$$

where  $\underline{s}$  = 0.97 - the ratio of the radiation of the sea surface to a black body

$\theta_{\text{sea}}$   $\theta_{\text{air}}$  = absolute temperature in ° C.;

$\sigma$  =  $1.175 \times 10^{-7}$  - the Stefan-Boltzmann constant;

$\underline{e}$  = vapor pressure (mb.);

$\underline{k}$  = constant <sup>4</sup>;

$\underline{C}$  = cloudiness in tenths.

Off the California coast, Roden (1959) has found that  $\underline{Q}_B$  varies from about 80 to 140 cal./cm.<sup>2</sup>/day and Seckel (1962) has found that, in the Hawaiian Islands region, values range from 115 to 150 cal./cm.<sup>2</sup>/day. At Triple Island, British Columbia, and at ocean station "Papa," Tabata (1958, 1961) has recorded average values of about 100 cal./cm.<sup>2</sup>/day with little seasonal variation.

The incoming radiation corrected for cloud cover minus that which is reflected and lost by back radiation may be called the "effective" radiation. Additional energy enters or leaves the sea surface as evaporation ( $\underline{Q}_E$ ) and sensible heat ( $\underline{Q}_H$ ). Jacobs (1951) discussed evaporation and conduction of sensible heat at length and presented seasonal charts of these values for the north Pacific Ocean.

Evaporation depends upon (1) the velocity of the wind and of the vapor pressure difference between the sea surface and air above it, and (2) a constant coefficient of proportionality. There is little agreement as to the value of the constant that should be used; the one selected for our computations is given by Tabata (1958):

$$\underline{Q}_E = 4.70 (\underline{e}_s - \underline{e}_a) \underline{W}$$

where  $\underline{e}_s$  = vapor pressure at temperature of sea surface (mb.);

$\underline{e}_a$  = vapor pressure of air (mb.);

and  $\underline{W}$  = wind speed (m./sec.).

Appendix Table B-4 lists values of saturation vapor pressure over water used in computation of evaporation.

In general, regions of greatest evaporation are those wherein northerly transport of surface water is greatest and which are subjected during winter to frequent invasions by cold, dry air masses from the interiors of continents. In the Pacific, this region is situated off Japan where cold dry air of continental Asiatic origin frequently traverses the northward-flowing, warm Kuroshio Current. Another region of high evaporation is in the trade wind zone as a result of relatively strong winds and dry, descending air associated with the semipermanent fields of high pressure (Jacobs, 1951). A region of low evaporation, in contrast, is in the eastern Pacific over the southward-flowing, cool California Current.

Bowen (1926) established the relation between evaporation and the heat exchange at a water surface. The equation used here is derived from the relation found by Bowen:

$$\underline{Q}_H = 3(\underline{T}_s - \underline{T}_a) \underline{W}$$

where  $\underline{T}_s$  = sea temperature (° C.);

$\underline{T}_a$  = air temperature (° C.);

and  $\underline{W}$  = wind speed (m./sec.).

Values of sensible heat exchange are generally low in summer and relatively high in winter but nowhere approach the magnitude of heat flux through evaporation.

Caution must be exercised in interpreting the energy exchange values in regions having limited observational coverage. Small errors in observation and transmission can cause large errors in some of the computations. In quadrangles having few observations, considerable bias can be introduced by the relative positions of the reporting ships and their timing with respect to the calendar month. All computations presented below assume the data centroid to be at the center of each respective quadrangle and for the middle of the calendar period involved. Energy exchange calculations are not performed for 5-degree quadrangles having fewer than five observations per month, though summarized meteorological data are listed.

Representative charts of the seasonal variation of total energy exchange and its components are presented for August 1963 and February 1964 in figures 26-37.

Until further experiments on the nature of the heat flux at the air-sea interface are completed, equation models are refined, and the

<sup>4</sup> Values for  $\underline{k}$  are given in Appendix table B-3.

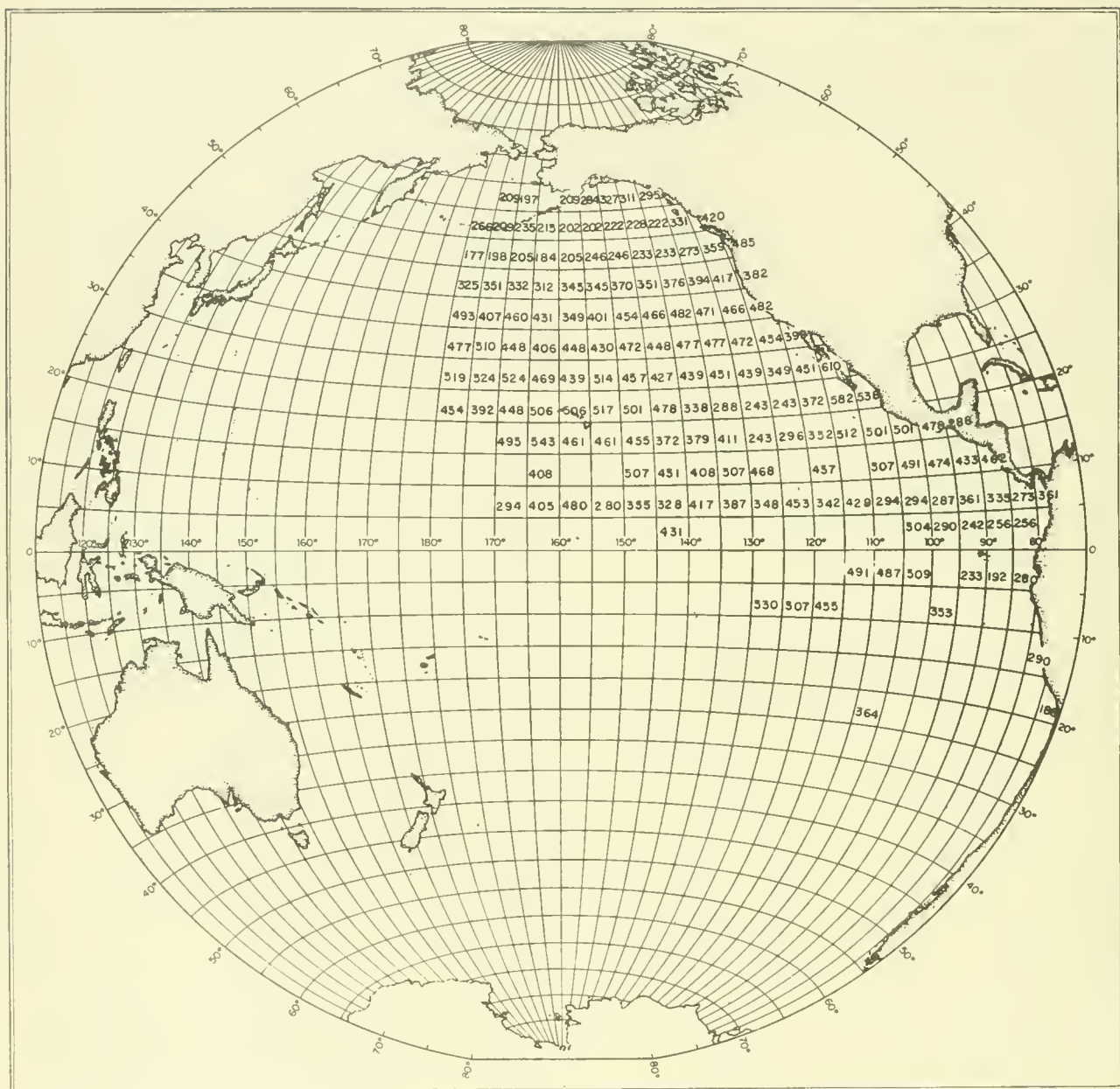


Figure 26.--Incoming radiation (cal./cm<sup>2</sup>/day) corrected for cloud cover, August 1963. All values positive.

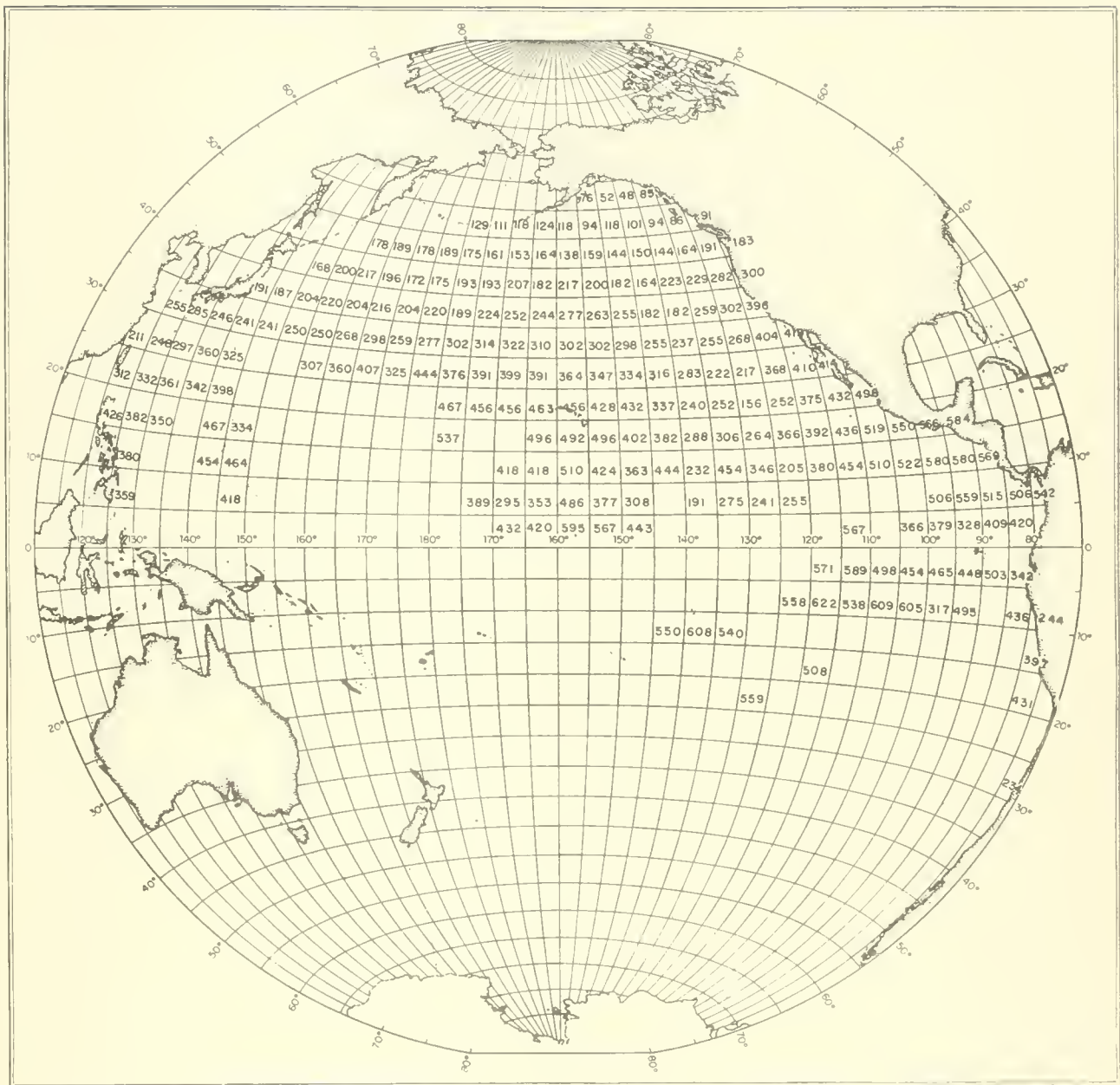


Figure 27.--Incoming radiation (cal./cm<sup>2</sup>/day) corrected for cloud cover, February 1964. All values positive.



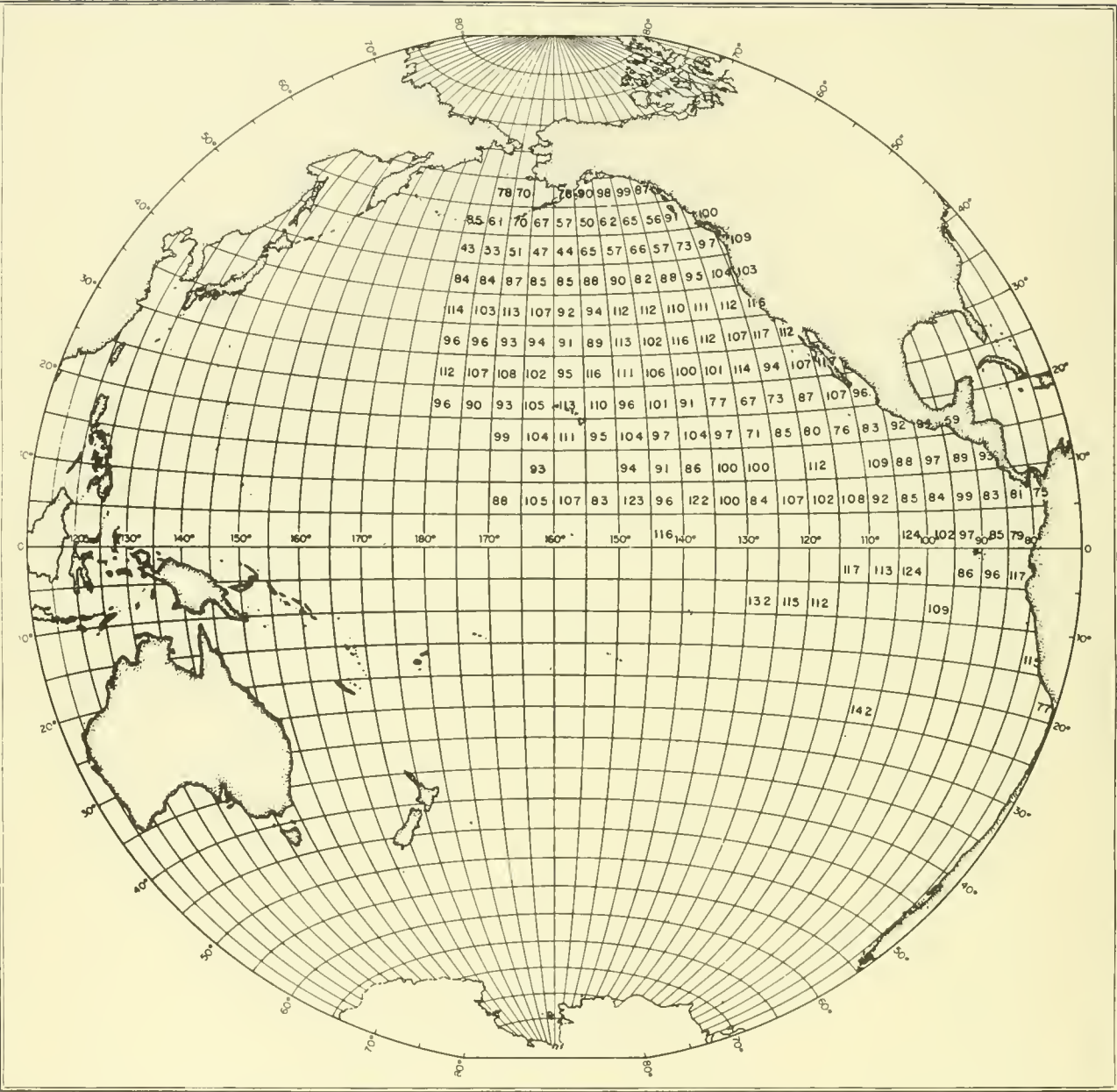


Figure 28.--Back radiation (cal./cm.<sup>2</sup>/day), August 1963. All values negative.



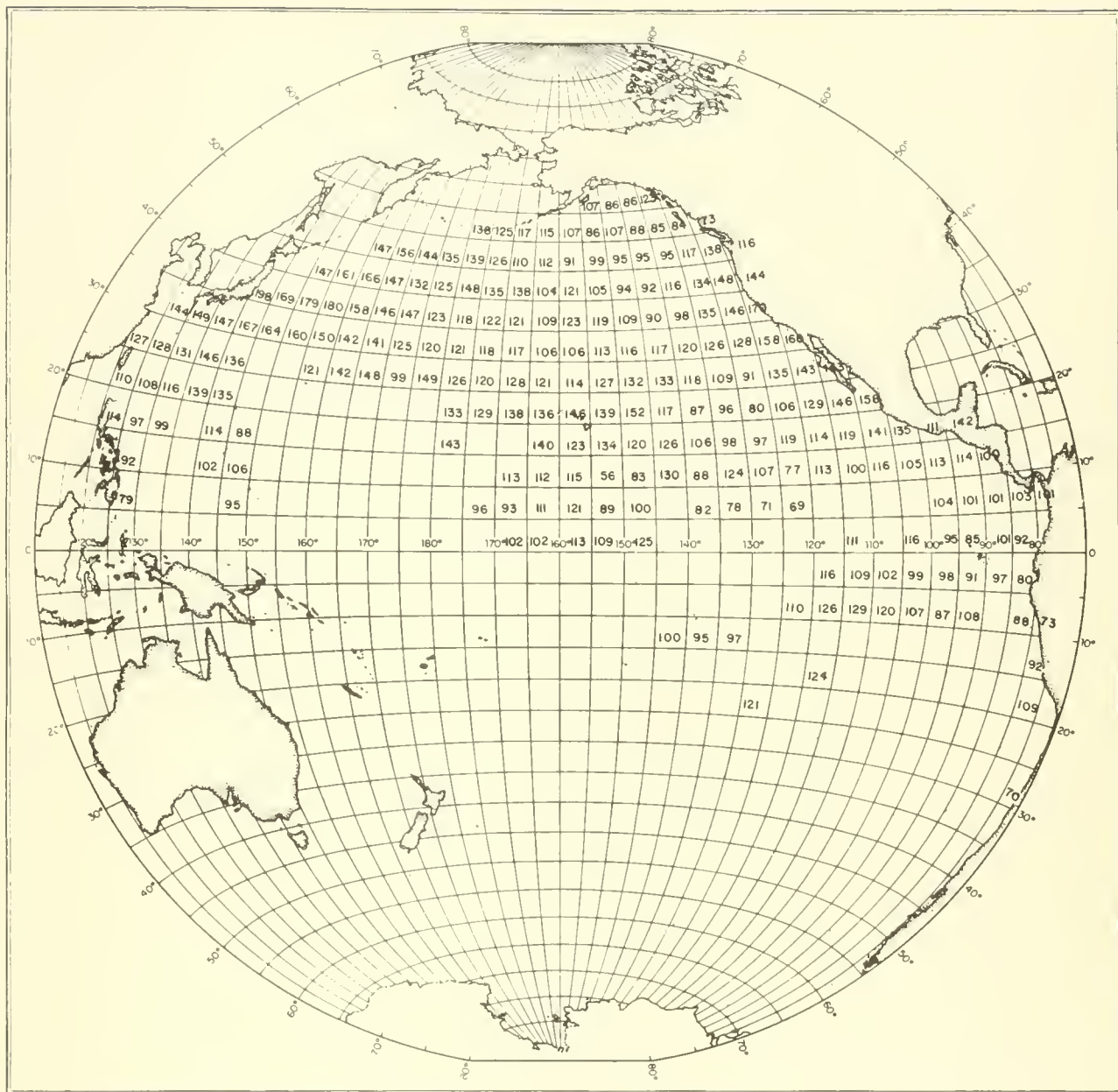


Figure 29.--Back radiation ( $\text{cal./cm}^2/\text{day}$ ), February 1964. All values negative.

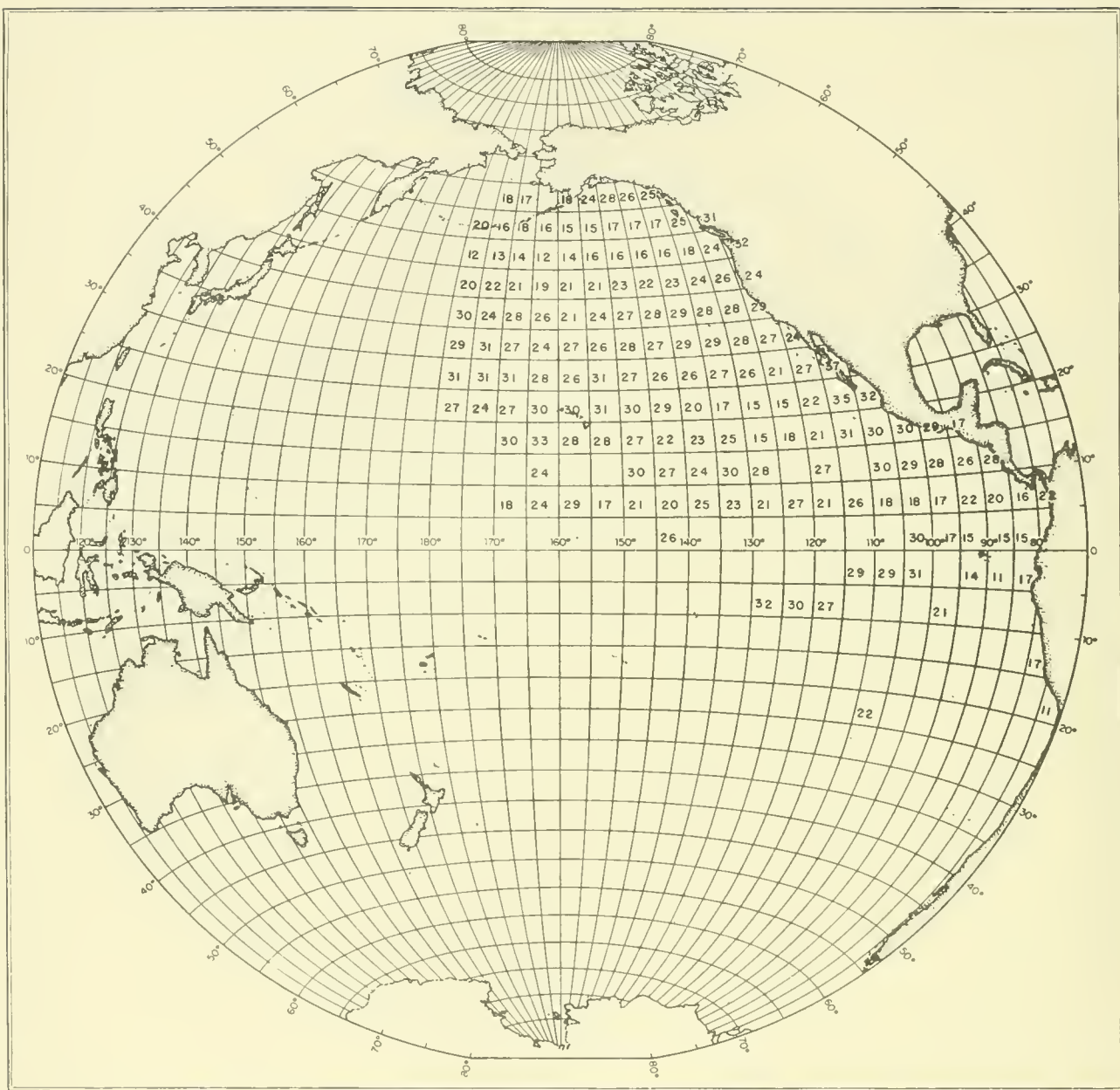


Figure 30.--Reflected radiation (cal./cm.<sup>2</sup>/day), August 1963. All values negative.

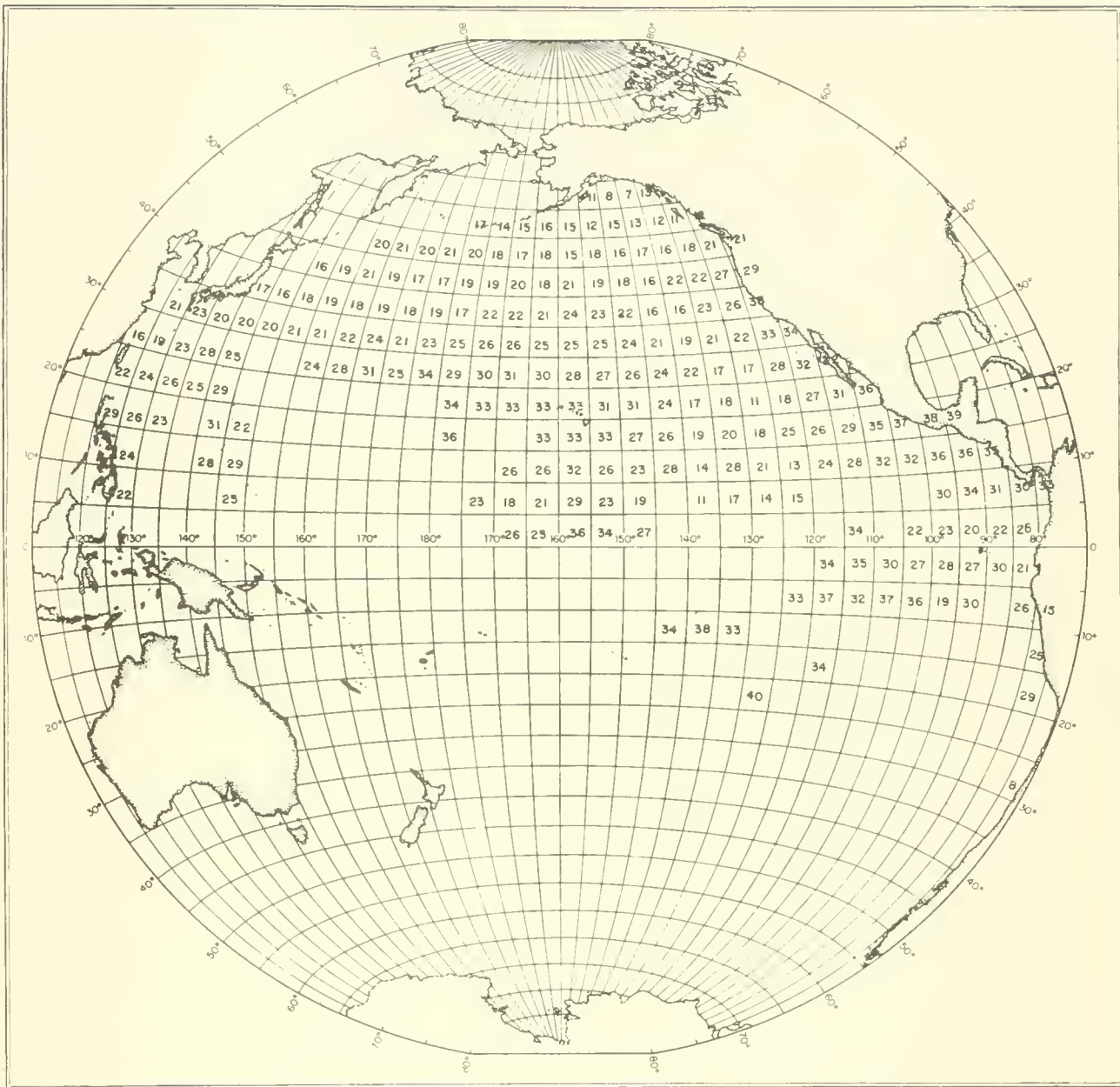


Figure 31.--Reflected radiation (cal./cm<sup>2</sup>/day), February 1964. All values negative.

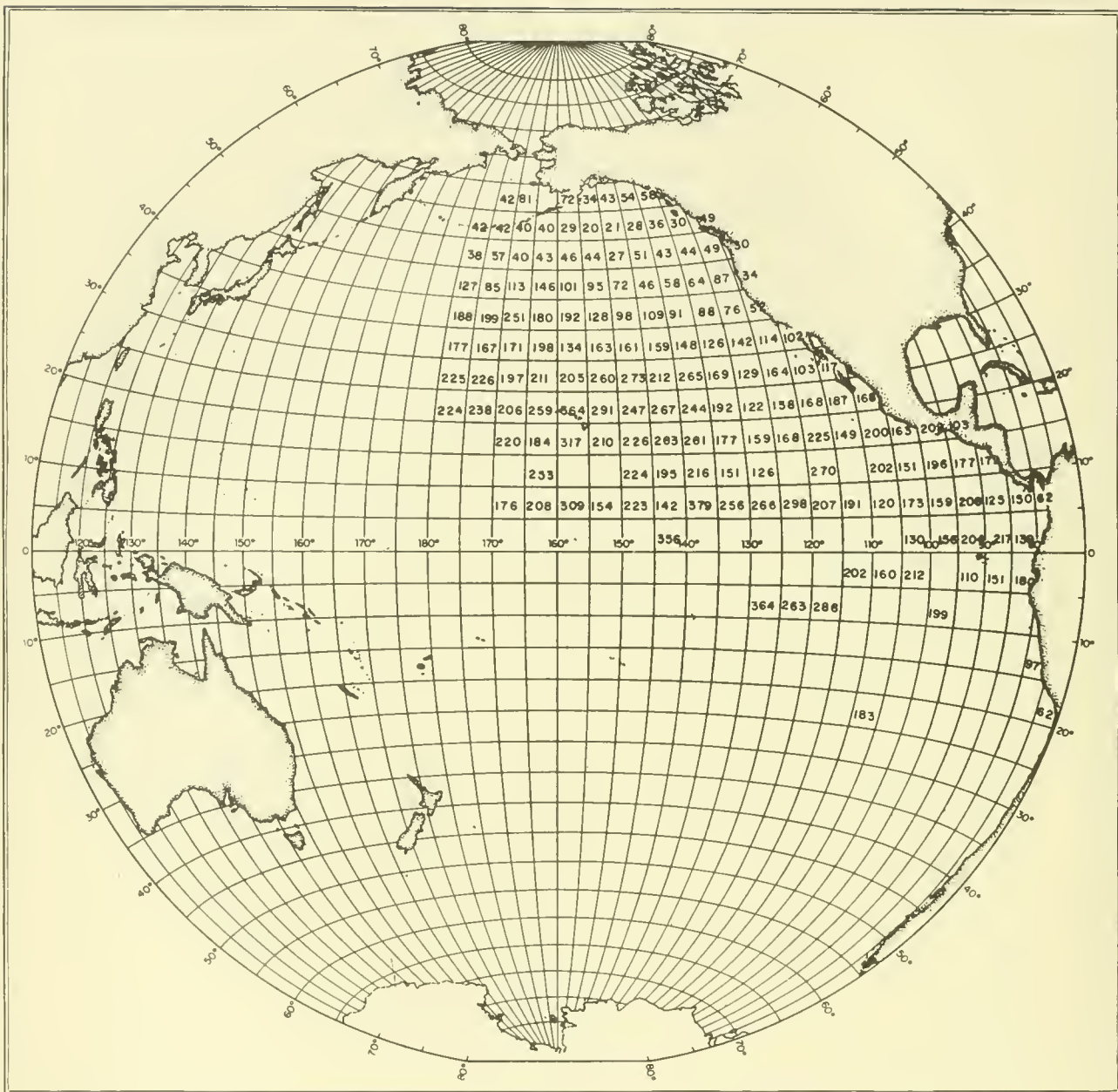


Figure 32.--Evaporation (cal./cm.<sup>2</sup>/day), August 1963. All values negative.



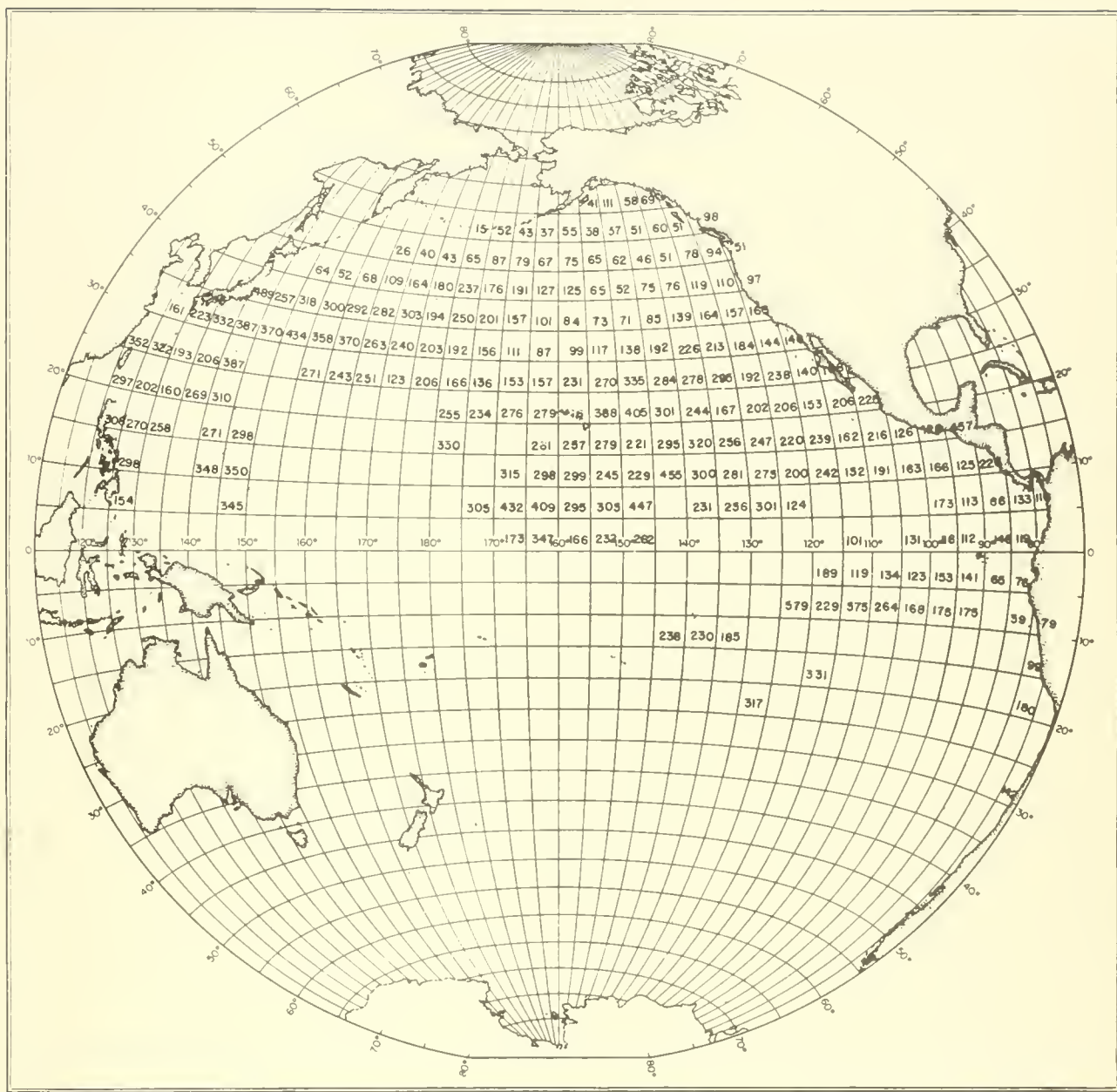


Figure 33.--Evaporation (cal./cm.<sup>2</sup>/day), February 1964. All values negative.

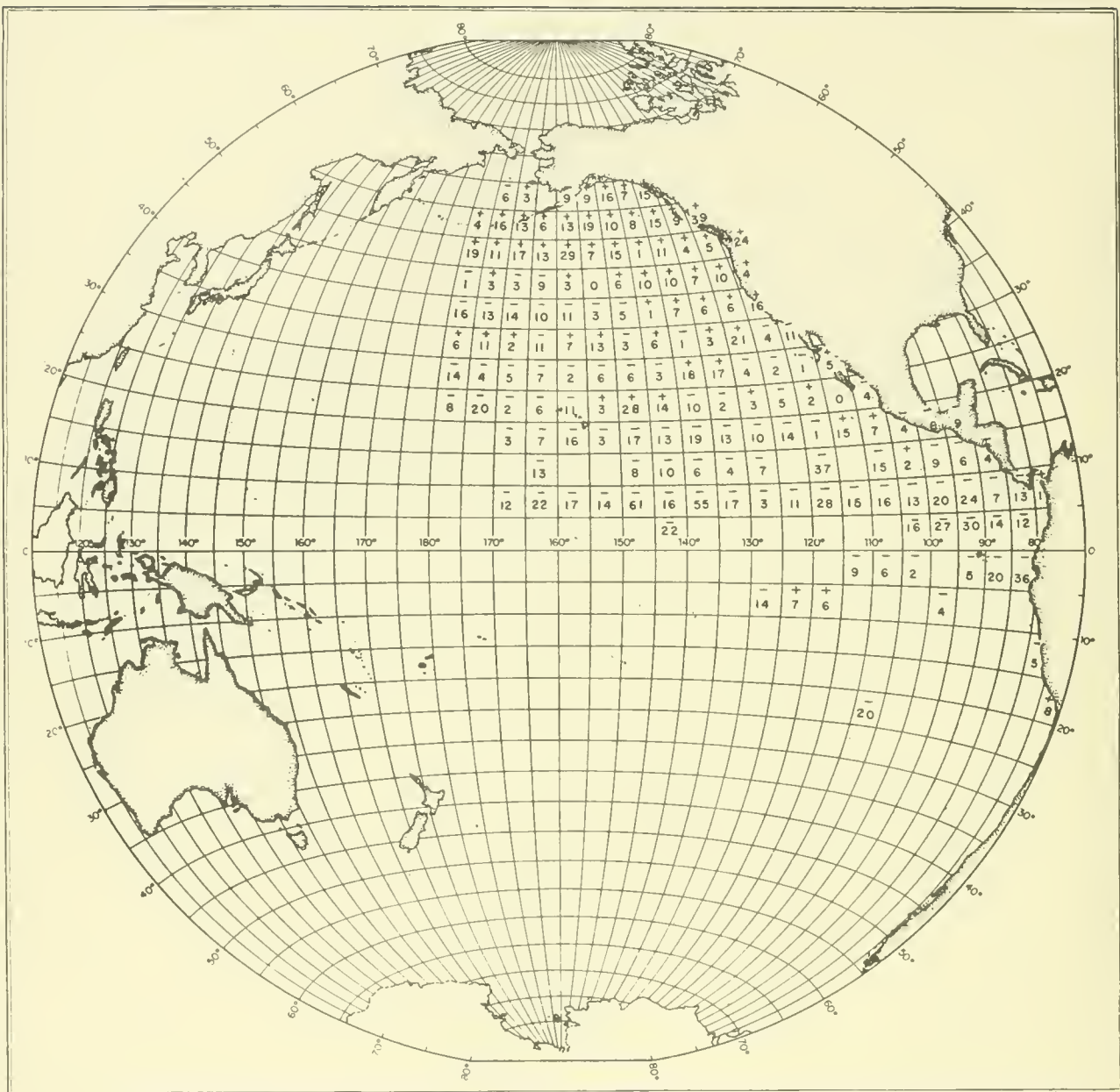


Figure 34.--Conduction of sensible heat (cal./cm<sup>2</sup>/day), August 1963.

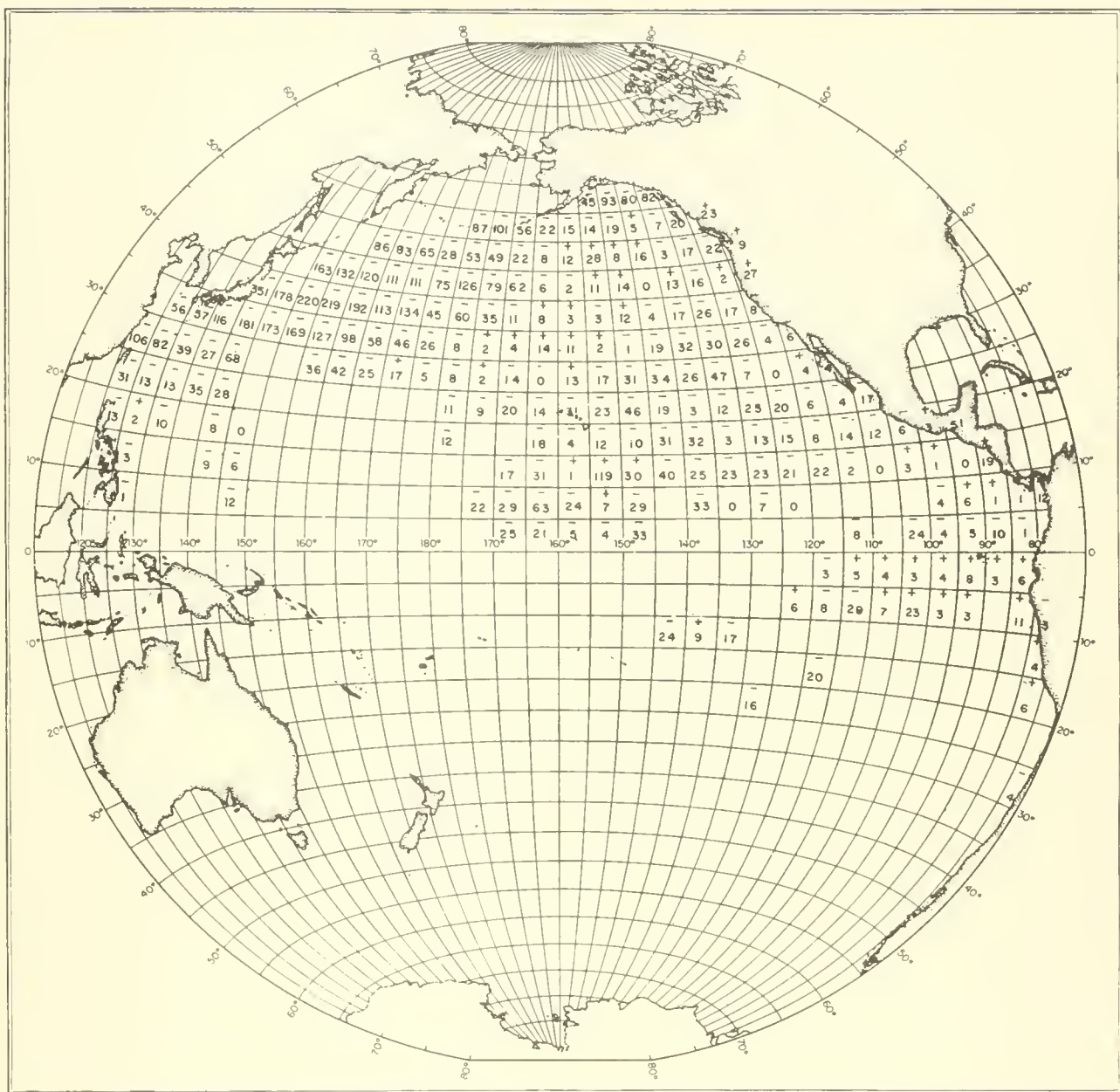


Figure 35.--Conduction of sensible heat (cal./cm<sup>2</sup>/day), February 1964.

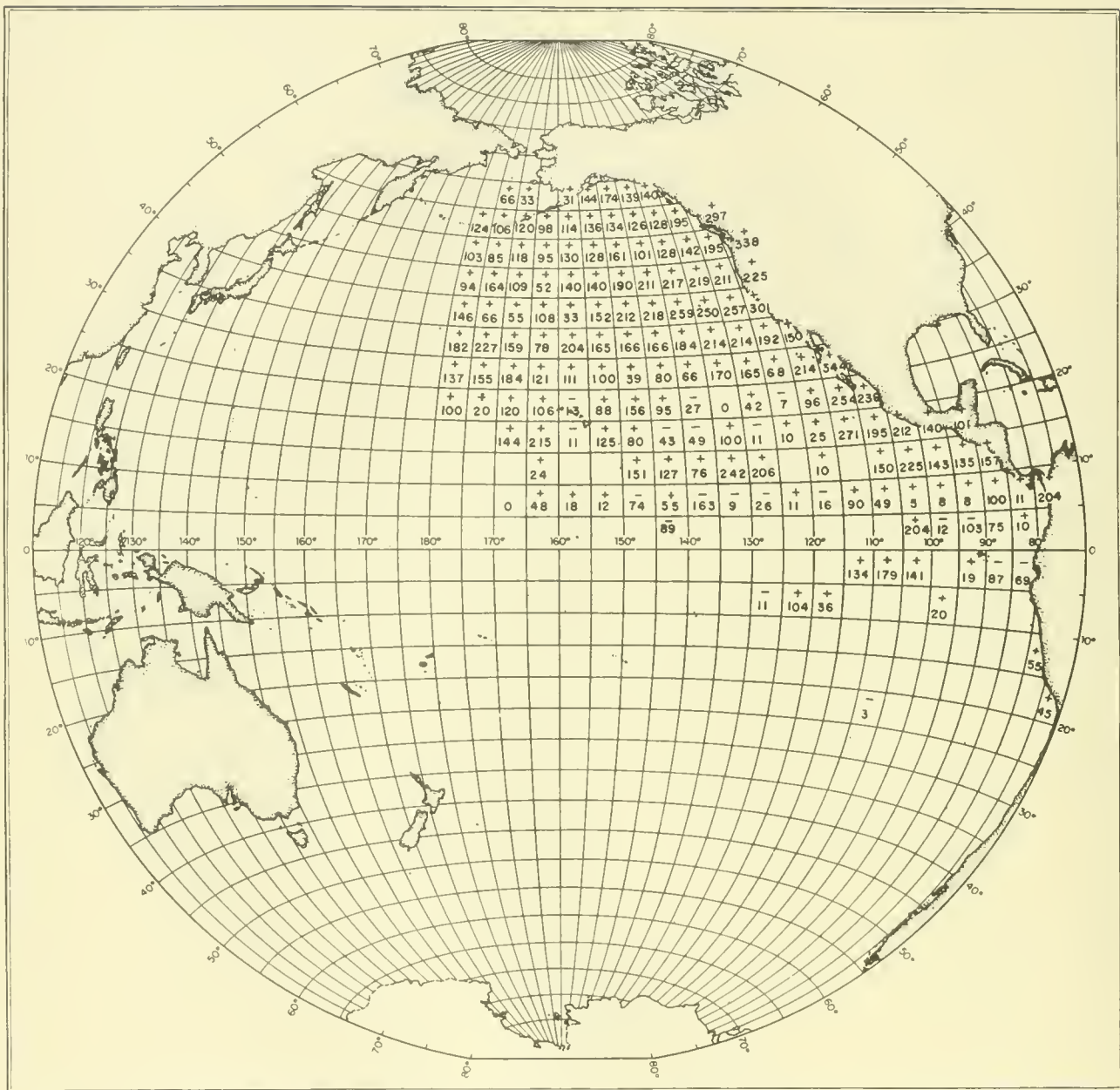


Figure 36.--Total energy exchange (cal./cm.<sup>2</sup>/day), August 1963.



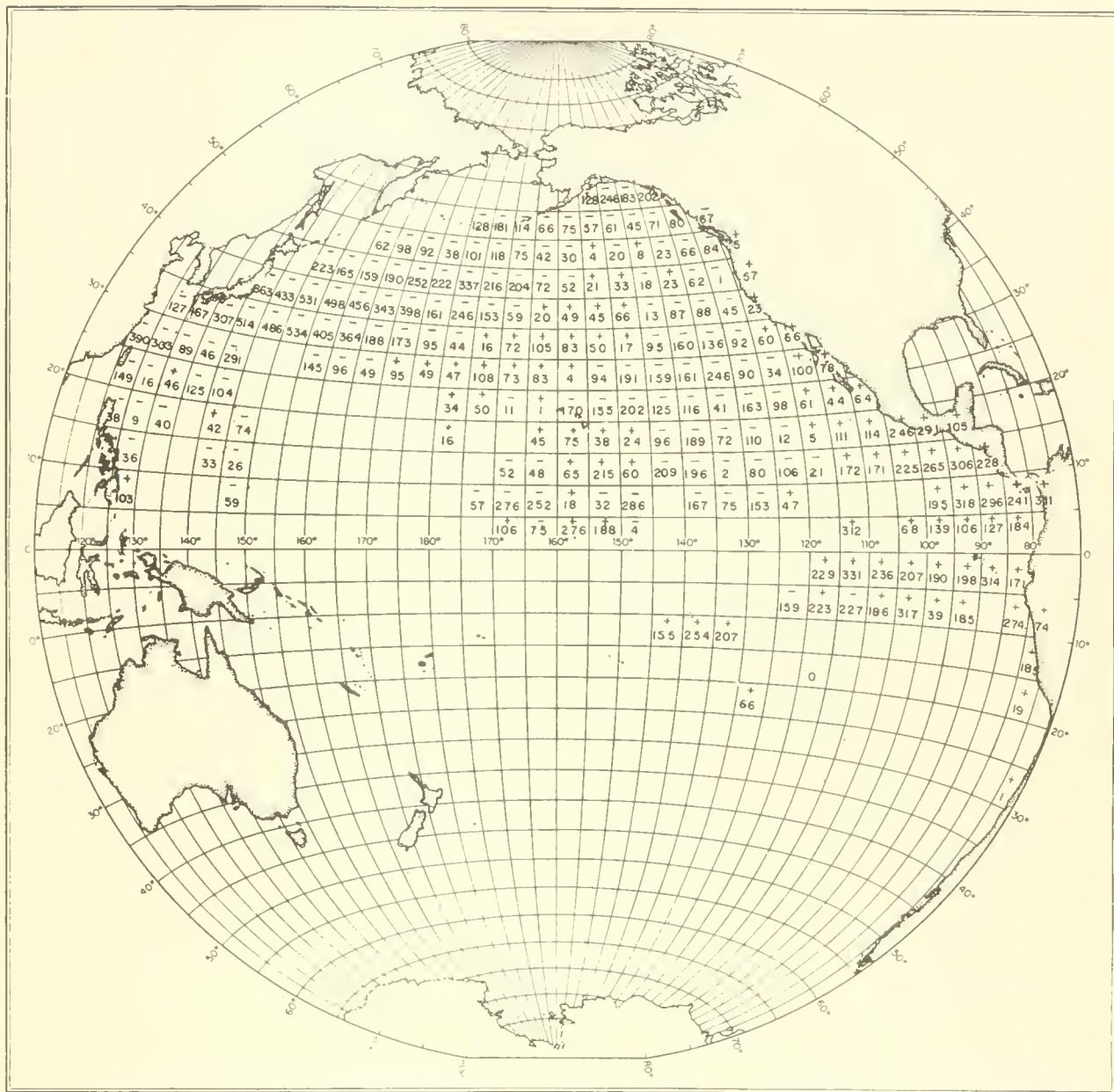


Figure 37.--Total energy exchange (cal./cm.<sup>2</sup>/day), February 1964.

accuracy of the synoptic marine weather report is improved, only broad scale features of the energy exchange will be considered. The real value of the heat budget charts as presented may be in showing year to year and month to month variations of each parameter.

Until such time as these computations can be improved more adequately to represent absolute values, they should be considered only as relative indices of the magnitude of the total energy flux which is taking place at the air-sea interface. On this basis, the data that are being produced routinely on a monthly schedule should stimulate further research efforts in this general subject area.

## ACKNOWLEDGMENTS

The authors wish to express their appreciation to John W. Martin, who developed the first machine-language program to summarize sea temperatures and portions of the meteorological data. Members of the Computer Center, University of California, San Diego, and its director, Clay L. Perry, assisted in resolving certain technical problems encountered during initial development of the program.

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## APPENDIX A

Listing of the FORTRAN-62 data processing program  
for synoptic marine weather reports conforming to the  
World Meteorological Organization code format FM 21.A.,  
International Surface Report from Ship in Full Form.





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27 FORMAT(2H0 A4, 10X, 10(F4.0,1X,F4.0,1X))
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28 FORMAT(2H0 A4, 3X, 3HPRAR, 2X, 10(F6.1,1H(, 12,1H)), / 10X, 2HX-,
1 3X, 10(I4, 1X, 1H(, 12, 1H), 1X), / 10X, 2HY-, 3X, 10(I4, 1X,
2 1H(, 12, 1H), 1X), / 9X, 3HVEL, 3X, 10(I4, 1X, 1H(, 12, 1H),
3 1X) )
C TWO DEGREE TEMPS...
29 FORMAT(2H0 A4, 13X, 5( 5X,F4.1,1X, 1H(, 13, 1H), F5.1))
C FIVE DEGREE FORMAT...
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1 49X,22H BIOLOGICAL LABORATORY /,
2 51X,18H SAN DIEGO, CALIF. ////,
3 42X,36H MARINE WEATHER OBSERVATION SUMMARY /,
4 56X, 8H FOR THE /,
5 53X,14H PACIFIC OCEAN //,
6 51X,18H FOR THE MONTH OF /,53X,A8,2H, ,14,10(/),
7 42X,16H DATE OF RUN,... ,A8,1X,12,2H, ,14, 7(/) )
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37 FORMAT(12A4)
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1 FAHRENHEIT) WITH NUMBER OF / 24X,56HOBSERVATIONS BY ONE-DEGREE QU
2ADRANGLES FOR THE MONTH OF ,A8,2H, ,14,1H. /)
41 FORMAT(1H0,26X,5HTABLE,F6.3,56H--SEA SURFACE TEMPERATURES (DEGREES
1 FAHRENHEIT) REJECTED /27X,52HREADINGS BY ONE-DEGREE QUADRANGLES F
2OR THE MONTH OF ,A8,2H, ,14,1H. /)
42 FORMAT(1H0,9X,5HTABLE,F6.3,89H--BAROMETRIC PRESSURES (MILLIBARS),
1X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED /12X,80H(KNO
2TS) WITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR THE
3MONTH OF ,A8,2H, ,14,1H. /)
43 FORMAT(1H0,28X,5HTABLE,F6.3,52H--BAROMETRIC PRESSURES (MILLIBARS)
1REJECTED READINGS /30X,44HBY ONE-DEGREE QUADRANGLES FOR THE MONTH
2OF ,A8,2H, ,14,1H. /)
44 FORMAT(1H0,17X,5HTABLE,F6.3,73H--SEA SURFACE TEMPERATURES (DEGREES
1 FAHRENHEIT AND CENTIGRADE) AND NUMBER /18X,60HOF OBSERVATIONS BY
2TWO-DEGREE QUADRANGLES FOR THE MONTH OF ,A8,2H, ,14,1H. /)
45 FORMAT(1H0,9X,5HTABLE,F6.3,91H--SEA SURFACE TEMPERATURES (DEGREES
1CENTIGRADE), AIR TEMPERATURES (DEGREES CENTIGRADE), DEW /8X,105HPO
2INT TEMPERATURES (DEGREES CENTIGRADE), BAROMETRIC PRESSURES (MILLI
3BARS), X- AND Y-WIND VECTORS (KNOTS), /6X,107HAVERAGE WIND SPE
4EDS (KNOTS), CLOUD COVER (TENTHS OF SKY COVERED), AND HEAT BUDGE
5T (CALORIES/CENTIMETER- /10X,86HSQUARED/DAY), WITH NUMBER OF OBS
6ERVATIONS BY FIVE-DEGREE QUADRANGLES FOR THE MONTH OF ,A8,2H, ,
7 14,1H. /)
46 FORMAT(1H1,////,51X,17HTABLE OF CONTENTS/9(/),1X,74HSEA SURFACE TE
1MPERATURES (DEGREES FAHRENHEIT) WITH NUMBER OF OBSERVATIONS //1X,
243HBY ONE-DEGREE QUADRANGLES FOR THE MONTH OF ,A8,2H, ,14,1H.,40X
3,13HTABLES 1.001-,F6.3,//////1X,95HBAROMETRIC PRESSURES (MILLIBARS)
4, X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED (KNOTS),//
51X,71HWITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR TH
6F MONTH OF ,A8,2H, ,14,1H. 12X,13HTABLES 2.001-,F6.3,//////1X,72H

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7SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT) AND NUMBER OF OBSERV
8ATIONS //1X,43HRY TWO-DEGREE QUADRANGLES FOR THE MONTH OF ,A8,
92H, ,14,1H. 40X,13HTABLES 3.001- F6.3/////
47 FORMAT(45X,24HNUMBER OF OBSERVATIONS 15/45X,24HNUMBER OF REJECTIO
1NS 15/45X,24HSUMMARIZED OBSERVATIONS 15/////////
2 42X,33H PROGRAMMED BY... MARVIN W. CLINE //
3 42X, 18H PROCESSED BY... 3A8)
48 FORMAT( 14X, 2(
1 11X, 39HQ(I) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H) ), / 14X,2(11X,
2 F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0) )
50 FORMAT(1X,85HSEA SURFACE TEMPERATURES (DEGREES CENTIGRADE), AIR TE
1MPERATURES (DEGREES CENTIGRADE), //1X,84HDEW POINT TEMPERATURES (D
2EGREES CENTIGRADE, BAROMETRIC PRESSURES (MILLIBARS), X- AND //1X,
383HY-WIND VECTORS (KNOTS), AVERAGE WIND SPEEDS (KNOTS), CLOUD
4COVER (TENTHS OF SKY //1X,76HCOVERED), AND HEAT BUDGET (CALORIES/C
5SENTIMETER-SQUARED/DAY), WITH NUMBER OF //1X,57HOBSERVATIONS BY FI
6VE-DEGREE QUADRANGLES FOR THE MONTH OF ,A8,2H, ,14,1H. ,
7 26X,13HTABLES 4.001- F6.3/1H1)
51 FORMAT(1H0,29X,15HLATITUDE RANGE ,A4,1H-,A4,12X,16HLONGITUDE RANGE
1 ,A4,1H-,A4/ /)
C * * * * *
C CONSTANTS...
A=15.0
R=15.0
DO 69 I=1,6
69 TABLE(I)=1
JK=10
JL=20
JM=30
JJJJ=0
KKKK=0
I3=10**3
I4=10**4
I5=10**5
I6=10**6
I7=10**7
I8=10**8
I9=10**9
I10=10**10
I11=10**11
I12=10**12
I13=10**13
C * * * * *
C READ IN PERM. TABLES...
READ 10, XK1, XK2
READ 11, HEAD, AHEAD, HEAD2, AHEAD2
READ 37, HEAD5, AHEAD5
READ 12, HEAT, REFLECT
READ 13, FS
C * * * * *
C READ HEADER CARD AND SET UP LIMITS...
C PULL PRECEDING CARD REPLACE WITHOUT STATEMENT NUMBER
6969 READ INPUT TAPE 10,16, LIMLATN, DIRN, LIMLATS, DIRS, LIMLONGW,
1 DIRW, LIMLONGE, DIRE, NO,AMONTH, IYEAR, MARK1, MARK2
READ INPUT TAPE 10, 33, XDATE, IDAY, JYEAR, XNAME
C READ MONTHLY TABLES...
READ INPUT TAPE 10,14, MEANSEA
READ INPUT TAPE 10,15, MEANRAR
IF (LIMLATN=6) 1000,1000,1006
1000 IF (DIRN=1HN) 1002,1001,1002
1001 LIMLATN=60-LIMLATN*10
GO TO 1007

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1002 IF (DIRN=1HS) 1004,1003,1004
1003 LIMLATN=60+LIMLATN*10
GO TO 1007
1004 IF (DIRN=1H ) 1006,1005,1006
1005 IF (LIMLAJN) 1006,1001,1006
1006 LIMLATN=0
1007 IF (LIMLAJS=6) 1107,1107,1013
1107 IF (DIRS=1HS) 1009,1008,1009
1008 LIMLATS=60+LIMLATS*10
GO TO 1014
1009 IF (DIRS=1HN) 1011,1010,1011
1010 LIMLATS=60-LIMLATS*10
GO TO 1014
1011 IF (DIRS=1H ) 1013,1012,1013
1012 IF (LIMLATS) 1013,1010,1013
1013 LIMLATS=120
1014 IF (LIMLATS-LIMLATN) 1015,1015,1016
1015 LIMLATN=0
LIMLATS=120
1016 IF (LIMLONGW) 1022,1116,1115
1115 IF (LIMLONGW=18) 1116,1116,1022
1116 IF (DIRW=1HW) 1018,1017,1018
1017 LIMLONGW=LIMLONGW*10
GO TO 1023
1018 IF (DIRW=1HE) 1020,1019,1020
1019 LIMLONGW=360-LIMLONGW*10
GO TO 1023
1020 IF (DIRW=1H ) 1022,1021,1022
1021 IF (LIMLONGW=18) 1022,1017,1022
1022 LIMLONGW=70
1023 IF (LIMLONGE=18) 1123,1123,1029
1123 IF (DIRF=1HE) 1025,1024,1025
1024 LIMLONGE=360-LIMLONGE*10
GO TO 1030
1025 IF (DIRF=1HW) 1027,1026,1027
1026 LIMLONGE=LIMLONGE*10
GO TO 1030
1027 IF (DIRF=1H ) 1029,1028,1029
1028 IF (LIMLONGE=18) 1029,1026,1029
1029 LIMLONGE=180
1030 IF (LIMLONGW-LIMLONGE) 1032,1031,1031
1031 LIMLONGW=70
LIMLONGE=180
1032 LONGCHK=LIMLONGW+10
LATN1=LIMLATN+1
LATS1=LIMLATS
LATN2=(LATN1+1)/2
LATS2=(LATS1+1)/2
LATN5=(LATN1+4)/5
LATS5=(LATS1+4)/5
IF (NO) 1033,1033,2033
2033 IF (NO=12) 1034,1034,1033
1033 NO=12
1034 CONTINUE
ICOUNT=C
ASSIGN 6000 TO NOT
6000 IF (UNIT, JK) 6000,6001,7003,7000
6001 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
C * * * * *
C ZERO ARRAYS...
1035 CALL ZERO (16920, ISEATEMP1
ASSIGN 6002 TO NOT

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C * * * * *
C DECODE DATA INTO ALPHANUMERIC AND NUMERIC FORMS, START PROGRAM...
103 ICOUNT=0
6002 IF (UNIT, JK) 6002, 104, 7003, 7000
104 DECODE ( 80, 17, IPUFFER1) ALPHA
DECODE ( 64, 18, IPUFFER1) BLANK
105 PUFFER IN (JK,0) (IPUFFER1(1),IPUFFER1(15))
C TESTS FOR XS AND BLANKS ALPHA AND NUMERIC
106 IF (ALPHA(19)-5H****) 107,204,107
107 I=0
5107 I=I+1
IF (BLANK(I)-1H ) 103,108,103
108 IF (I-10) 5107,5108,5108
5108 IF (DOLT(ALPHA(1),1)) 103,110,103
110 DECODE (8, 35, ALPHA(1)) IOCTANT
IOCTANT=IOCTANT/I7
IF (DOLT(ALPHA(2),2)) 103,112,103
112 DECODE (8, 35, ALPHA(2)) ILAT
ILAT=ILAT/I6
IF (DOLT(ALPHA(3),2)) 103,114,103
114 DECODE (8, 35, ALPHA(3)) ILONG
ILONG=ILONG/I6
C * * * * *
C COMPUTATION OF LONG AND LAT SUBSCRIPTS FOR 1 DEG, 2 DEG AND 5 DEG
C ARRAYS...
117 IDUMMY=IOCTANT+1
GO TO (118,118,118,118,103,119,119,119,103), IDUMMY
118 LAT=60-ILAT
GO TO 600
119 LAT=61+ILAT
600 IF (LAT-LIMLATN) 103,103,601
601 IF (LAT-LIMLATN) 122,103,103
122 MLAT=(LAT+4)/5
KLAT=(LAT+1)/2
123 GO TO (125,126,129,131,103,125,126,129,131,103), IDUMMY
126 IF (ILONG-80) 127,103,125
127 ILONG=ILONG+100
125 LONG=10-ILONG+ILONG/10*10
ILONG=ILONG+1
124 MLONG=(LONG+4)/5
KLONG=(LONG+1)/2
GO TO 135
129 IF (ILONG-80) 130,103,131
130 ILONG=ILONG+100
131 LONG=1+ILONG-ILONG/10*10
ILONG=360-ILONG
GO TO 124
135 JLONG=(ILONG-4)/5
C * * * * *
C IS CARD IN LIMITS...
IF (MEANSFA(JLONG,MLAT)) 103,999,999
999 IF (LONGCHK-ILONG) 103,136,136
136 IF (ILONG-LONGCHK+10) 103,103,137
C * * * * *
C ZERO INDICATOR SEARCH...
137 I=7
5137 I=I+3
IF (ALPHA(I)-1H0) 138,139,138
138 IF (I-16) 5137,175,175
C * * * * *
C SEA TEMPERATURE SUBROUTINE...
139 IF (DOLT(ALPHA(9),2)) 175,141,175

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141 DECODE (8, 35, ALPHA(9)) ITEMP
ITEMP=ITEMP/I6
IF (DOLT(ALPHA(I+1),2)) 175,142,175
142 DECODE (8, 35, ALPHA(I+1)) IDIFF
IDIFF=IDIFF/I6
C SUR-ZFRO AND OTHER JUNK SUBROUTINE...
IF (LONGCHK-180) 9550,9550,9500
9500 IF (NO-3) 9510,9510,143
9510 IF (LAT-20) 9530,9530,9520
9520 IF (LAT-101) 143,9530,9530
9530 IF (ITEMP-50) 143,143,9540
9540 ITEMP=50-ITEMP
GO TO 143
9550 IF (NO-3) 9560,9560,8001
9560 IF (LAT-20) 9580,9580,9570
9570 IF (LAT-101) 8001,9580,9580
9580 IF (ITEMP-50) 8001,8001,9590
9590 IF (ITEMP-79) 9600,9600,9610
9600 ITEMP=50-ITEMP
GO TO 143
9610 ITEMP=ITEMP-100
GO TO 147
8001 IF (NO-3) 9710,9710,9700
9700 IF (NO-12) 9730,9710,9730
9710 IF (LAT-40) 9720,9720,9730
9720 IF (ITEMP-30) 143,147,147
9730 IF (ITEMP-36) 143,147,147
143 IF (IDIFF-50) 145,144,144
144 JTEMP=ITEMP*10+(IDIFF-50)*10/2
XDUMMY=IDIFF
DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)+(XDUMMY-50.0)/2.0
GO TO 146
145 JTEMP=ITEMP*10-IDIFF*10/2
XDUMMY=IDIFF
DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)-XDUMMY/2.0
C STATEMENT 146 CONVERTS TEMP FROM C TO F...
146 JTEMP=(JTEMP*180)/100+320
GO TO 150
147 IF (IDIFF-50) 148,149,149
148 JTEMP=(ITEMP-IDIFF)*10
XDUMMY=IDIFF
DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)-XDUMMY/1.8
GO TO 150
149 JTEMP=(ITEMP+IDIFF-50)*10
XDUMMY=IDIFF
DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)+(XDUMMY-50.0)/1.8
150 COUNT(MLONG,MLAT)=COUNT(MLONG,MLAT)+1.0
C COMPARE WITH MEAN TEMP...
N=LAT-LAT/10*10
IF (N) 103,151,152
151 N=10
152 IFINK=MEANSEA(JLONG,MLAT)
LIMIT=IFINK/1000
IF (IFINK) 103,160,153
153 IF (N-3) 154,161,162
154 NN=3
155 NNN=-1
157 IF (MLAT-1) 103,161,158
163 NN=B
NNN=1
156 IF (MLAT-24) 158,161,103
158 IF (MEANSEA(JLONG,MLAT+NNN)) 161,161,5158

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5158 IMEAN=IFINK-LIMIT*1000-(IFINK-LIMIT*1000-MEANSEA(JLONG,MLAT+NNN)+
1 MEANSEA(JLONG,MLAT+NNN)/1000*1000)*XABSF(NN-N)/5
159 IF (XABSF(JTEMP-IMEAN)-LIMIT*10) 160,160,167
160 ISEATEMP(LONG,LAT)=JTEMP+ISEATEMP(LONG,LAT)
ISEA(LONG,LAT)=ISEA(LONG,LAT)+1
JSEATEMP(KLONG,KLAT)=JSEATEMP(KLONG,KLAT)+JTEMP
JSEA(KLONG,KLAT)=JSEA(KLONG,KLAT)+1
KSFATEMP(MLONG,MLAT)=KSEATEMP(MLONG,MLAT)+(JTEMP-320)*100/180
KSEA(MLONG,MLAT)=KSEA(MLONG,MLAT)+1
GO TO 170
161 IMEAN=IFINK-LIMIT*1000
GO TO 159
162 IF (N-8) 164,161,163
164 IF (N-6) 165,166,166
165 NN=3
NNN=1
GO TO 158
166 NN=8
NNN=-1
GO TO 158
C REJECT ARRAY FILL...
167 IF (JTEMP) 103,9167,9167
9167 IF (MARKT) 1167,103,1167
1167 DO 168 J=1,3
IF (IREJT(LONG,LAT)-J) 169,168,168
168 CONTINUE
JJJ=JJJ+1
GO TO 103
169 ITEMPREJ(LONG,LAT)=ITEMPREJ(LONG,LAT)+JTEMP/10*10**((J-1)*3)
IREJT(LONG,LAT)=IREJT(LONG,LAT)+1
JJJ=JJJ+1
GO TO 103
C * * * * *
C DEW POINT SUBROUTINE...
170 IF (DOLT(ALPHA(1+2),2)) 175,171,175
171 DECODE (8, 35, ALPHA(1+2)) IDEWPT
IDEWPT=IDEWPT/15
8002 IF (IDEWPT-990) 5170,103,103
5170 IF (JTEMP-36) 5171,5172,5172
5171 IDEWPT=IDEWPT*180/100+320
5172 IF (XABSF(IDEWPT-JTEMP)-200) 172,172,175
172 IDEWPT(MLONG,MLAT)=JDEWPT(MLONG,MLAT)+IDEWPT
JDEW(MLONG,MLAT)=JDEW(MLONG,MLAT)+1
C * * * * *
C CLOUD COVER SUBROUTINE...
175 IF (DOLT(ALPHA(4),1)) 181,177,181
177 DECODE (8, 35, ALPHA(4)) ICLOUD
ICLOUD=ICLOUD/17
8003 IF (ICLOUD-9) 180,178,181
178 IF (DOLT(ALPHA(7),2)) 181,800,181
800 DECODE (8, 35, ALPHA(7)) IVIS
IVIS=IVIS/16
IF (IVIS-90) 2000,2001,179
179 IF (IVIS-93) 2001,2001,181
2000 IF (IVIS-5) 2001,2001,181
2001 ICLOUD=8
180 JCLOUD(MLONG,MLAT)=JCLOUD(MLONG,MLAT)+(ICLOUD*100/8)
JCLO(MLONG,MLAT)=JCLO(MLONG,MLAT)+1
C * * * * *
C BAROMETER SUBROUTINE...
181 IF (DOLT(ALPHA(8),3)) 103,183,103
183 DECODE (8, 35, ALPHA(8)) IPRESS

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      IPRESS=IPRESS/15
8004 IF (IPRESS-500) 184,103,185
184 IPRESS=IPRESS+10000
      GO TO 186
185 IPRESS=IPRESS+9000
186 IFINK=MEANBAR(JLONG,MLAT)
      LIMIT=IFINK/10000
      IF (IFINK) 103,189,6500
6500 N=LAT-LAT/10*10
      IF (N) 103,700,701
700 N=10
701 IF (N-3) 702,6700,704
702 NN=3
      NNN=-1
      GO TO 6501
704 IF (N-8) 706,6700,705
705 NN=8
      NNN=1
      GO TO 703
706 IF (N-6) 707,708,708
707 NN=3
      NNN=1
      GO TO 187
708 NN=8
      NNN=-1
      GO TO 187
703 IF (MLAT-24) 187,6700,103
6501 IF (MLAT-1) 103,6700,187
6700 IMEAN=IFINK-LIMIT*10000
      GO TO 188
187 IF (MEANBAR(JLONG,MLAT+NNN)) 6700,6700,5187
5187 IMEAN=IFINK-LIMIT*10000-(IFINK-LIMIT*10000-MEANBAR(JLONG,MLAT+NNN)
      1+MEANBAR(JLONG,MLAT+NNN)/10000*10000)*XABSF(NN-N)/5
188 IF (XABSF(IPRESS-IMEAN)-LIMIT*10) 189,189,190
189 IBAROM(LONG,LAT)=IBAROM(LONG,LAT)+IPRESS
      IBAR(LONG,LAT)=IBAR(LONG,LAT)+1
      KBAROM(MLONG,MLAT)=KBAROM(MLONG,MLAT)+IPRESS
      KBAR(MLONG,MLAT)=KBAR(MLONG,MLAT)+1
      GO TO 193
C REJECT ARRAY FILL...
190 IF (MARKB) 1190,103,1190
1190 DO 191 J=1,2
      IF (IREJB(LONG,LAT)-J) 192,191,191
191 CONTINUE
      JJJ=JJJ+1
      GO TO 103
192 IBAROREJ(LONG,LAT)=IBAROREJ(LONG,LAT)+IPRESS/10*10**((J-1)*6)
      IREJB(LONG,LAT)=IREJB(LONG,LAT)+1
      JJJ=JJJ+1
      GO TO 103
C * * * * *
C WIND SUBROUTINE...
193 IF (DOLT(ALPHA(6),2)) 103,195,103
195 DECODE (8, 35, ALPHA(6)) IVEL
      IVEL=IVEL/16
196 IF (DOLT(ALPHA(5),2)) 103,198,103
198 DECODE (8, 35, ALPHA(5)) IDIR
      IDIR=IDIR/16
      IF (IDIR) 103,197,199
197 IVEL=0
      GO TO 202
199 IF (IDIR-51) 202,200,200

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200 IF (IDIR-99) 201,103,103
201 IDIR=IDIR-50
   IVFL=IVFL+100
202 IDIR=IDIR*10
   VFL=IVFL
   XDUMMY=IDIR
   IX=SINF(XDUMMY*0.0174)*VEL*(-1.0)
   IY=COSE(XDUMMY*0.0174)*VEL*(-1.0)
   KWINDIRX(MLONG,MLAT)=KWINDIRX(MLONG,MLAT)+IX
   KWINDIRY(MLONG,MLAT)=KWINDIRY(MLONG,MLAT)+IY
   KWIND(MLONG,MLAT)=KWIND(MLONG,MLAT)+1
   IWINDIRX(LONG,LAT)=IWINDIRX(LONG,LAT)+IX
   IWINDIRY(LONG,LAT)=IWINDIRY(LONG,LAT)+IY
   IWIND(LONG,LAT)=IWIND(LONG,LAT)+1
203 IWINDVEL(LONG,LAT)=IWINDVEL(LONG,LAT)+IVEL
   IWINDV(LONG,LAT)=IWINDV(LONG,LAT)+1
   KWINDVEL(MLONG,MLAT)=KWINDVEL(MLONG,MLAT)+IVEL
   KWINDV(MLONG,MLAT)=KWINDV(MLONG,MLAT)+1
   GO TO 103
C * * * * *
C START OF HEAT EQUATIONS AND OUTPUT SUBROUTINES
C ONE DEGREE OUTPUT (TEMPS ONLY) ...
C NOTE... TWO REELS ARE REQUIRED FOR OUTPUT IF IT IS INDICATED ON THE
C HEADER CARD THAT REJECTS ARE DESIRED.
204 IF (ALPHA(20)-5H*****) 5204,5247,5204
5204 IF ((TABLE(1)-1.0)*39.0+(TABLE(2)-2.0)*57.0+(TABLE(3)-3.0)*39.0+
1 (TABLE(4)-4.0)*71.0-A) 5206,5205,5205
5205 CALL CHANGE (JL,A)
5206 IF ((TABLE(5)-5.0)*39.0+(TABLE(6)-6.0)*39.0-B) 5208,5207,5207
5207 CALL CHANGE (JM,B)
5208 M=LONGCHK-9
   TABLE(1)=TABLE(1)+0.001
   TABLE(5)=TABLE(5)+0.001
   LINF=0
4000 WRITE OUTPUT TAPE JL, 19,
   WRITE OUTPUT TAPE JL, 40, TABLE(1), AMONTH, IYEAR
   WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
   WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M,LONGCHK)
4002 IF (MARKT) 205,206,205
205 WRITE OUTPUT TAPE JM, 19,
   WRITE OUTPUT TAPE JM, 41, TABLE(5), AMONTH, IYEAR
   WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
   WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M,LONGCHK)
206 DO 214 J=LATN1, LATS1
   DO 212 I=1,10
   IC1(I)=ISFA(I,J)
   IF (IC1(I)) 210,210,207
207 IC2(I)=ISFATEMP(I,J)/IC1(I)
   IF (IC2(I)-IC2(I)/10*10-5) 208,209,209
208 XIC2(I)=IC2(I)/10
   GO TO 5000
209 XIC2(I)=(IC2(I)+5)/10
   GO TO 5000
210 XIC2(I)=0.0
5000 IF (MARKT) 211,212,211
211 IREJ(I*3-2)=ITEMPREJ(I,J)/16
   IREJ(I*3-1)=(ITEMPREJ(I,J)-IREJ(I*3-2)* 16 )/13
   IREJ(I*3)=ITEMPREJ(I,J)-IREJ(I*3-2)* 16 -IREJ(I*3-1)*13
   XREJ(I*3-2)=IREJ(I*3-2)
   XREJ(I*3-1)=IREJ(I*3-1)

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-----XREF(J(I*2))=IREF(J(I*3))-----
212 CONTINUE
LINE=LINE+1
IF (LINE-30) 4005,4005,9000
9000 TABLE(1)=TABLE(1)+0.001
LINE=1
9001 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 40, TABLE(1), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M, LONGCHK)
9002 IF (MARKT) 9004,4005,9004
9004 TABLE(5)=TABLE(5)+0.001
9005 WRITE OUTPUT TAPE JM, 19,
WRITE OUTPUT TAPE JM, 41, TABLE(5), AMONTH, IYEAR
WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M, LONGCHK)
4005 WRITE OUTPUT TAPE JL, 25, HEAD(J), (XIC2(I), IC1(I), I=1,10)
4007 IF (MARKT) 213,214,213
213 WRITE OUTPUT TAPE JM, 26, HEAD(J), XREF
214 CONTINUE
C * * * * *
C REMAINDER OF ONE DEGREE OUTPUT...
TABLE(2)=TABLE(2)+0.001
TABLE(6)=TABLE(6)+0.001
LINE=0
JLINE=0
2215 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 42, TABLE(2), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M, LONGCHK)
4215 IF (MARKR) 215,216,215
215 WRITE OUTPUT TAPE JM, 19,
WRITE OUTPUT TAPE JM, 43, TABLE(6), AMONTH, IYEAR
WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M, LONGCHK)
216 DO 226 J=LATN1, LATS1
DO 224 I=1,10
IC2(I)=IRAR(I,J)
IF (IC2(I)) 218,218,217
217 BAROM(I)=IRAROM(I,J)/IC2(I)
BAROM(I)=BAROM(I)/10.0
GO TO 5001
218 BAROM(I)=0.0
5001 IC3(I)=IWIND(I,J)
IF (IC3(I)) 220,220,219
219 IC5(I)=IWINDIRX(I,J)/IC3(I)
IC4(I)=IWINDIRY(I,J)/IC3(I)
GO TO 5002
220 IC4(I)=0
IC5(I)=0
5002 IC6(I)=IWINDV(I,J)
IF (IC6(I)) 222,222,221
221 IWINDVEL(I,J)=IWINDVEL(I,J)/IC6(I)
GO TO 5003
222 IWINDVEL(I,J)=0
5003 IF (MARKR) 223,224,223
223 IREF(J(I*2-1))=IRAREF(J(I,J)/16
IREF(J(I*2))=IRAREF(J(I,J))-IREF(J(I*2-1))*16

```



```

-----XRFJ(I*2-1)=IREJ(I*2-1)
XRFJ(I*2)=IREJ(I*2)
224 CONTINUE
LINE=LINE+1
JLINE=JLINE+1
IF (LINE-12) 9010,9010,9007
9007 TABLE(2)=TABLE(2)+0.001
LINE=1
9008 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 42, TABLE(2), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M, LONGCHK)
9010 IF (MARKR) 9011,4011,9011
9011 IF (JLINE-30) 4011,4011,9012
9012 JLINE=1
TABLE(6)=TABLE(6)+0.001
WRITE OUTPUT TAPE JM, 19,
WRITE OUTPUT TAPE JM, 43, TABLE(6), AMONTH, IYEAR
WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
1 AHEAD(LONGCHK)
WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M, LONGCHK)
4011 WRITE OUTPUT TAPE JL,28, HEAD(J), (BAROM(I),IC2(I), I=1,10),
1 (IC5(I),IC3(I), I=1,10), (IC4(I),IC3(I), I=1,10),
2 ((I*WINDVEL(I,L), IC6(I), I=1,10), L=J,J)
4013 IF (MARKR) 225,226,225
225 WRITE OUTPUT TAPE JM,27, HEAD(J), (XREJ(L),L=1,20)
226 CONTINUE
C * * * * *
C TWO DEGREE OUTPUT LOOPS...
TABLE(3)=TABLE(3)+0.001
LINE=0
2227 M=LONGCHK/2
L=M-4
4015 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 44, TABLE(3), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 20, HEAD2(LATN2), HEAD2(LATS2),AHEAD2(L),
1 AHEAD2(M)
WRITE OUTPUT TAPE JL, 22, (AHEAD2(I), I=L,M)
4017 DO 229 J=LATN2, LATS2
DO 5004 I=1,5
IC1(I)=JSFA(I,J)
IF (IC1(I)) 228,228,227
227 IC2(I)=JSFATEMP(I,J)/IC1(I)
XIC2(I)=IC2(I)
XIC2(I)=XIC2(I)/10.0
BAROM(I)=(XIC2(I)-32.0)/1.8
GO TO 5004
228 XIC2(I)=0.0
BAROM(I)=0.0
5004 CONTINUE
LINE=LINE+1
IF (LINE-32) 5229,5229,9014
9014 TABLE(3)=TABLE(3)+0.001
LINE=1
9015 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 44, TABLE(3), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 20, HEAD2(LATN2), HEAD2(LATS2),AHEAD2(L),
1 AHEAD2(M)
WRITE OUTPUT TAPE JL, 22, (AHEAD2(I), I=L,M)
5229 WRITE OUTPUT TAPE JL,29, HEAD2(J),XIC2(I),IC1(I),BAROM(I),
1 I=1,5)

```

```

-----229 CONTINUE-----
C * * * * *
C FIVE DEGREE OUTPUT LOOPS...
TABLE(4)=TABLE(4)+0.001
LINE=0
4019 M=LONGCHK/5
L=M-1
4020 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 45, TABLE(4), AMONTH, IYEAR
WRITE OUTPUT TAPE JL, 51, HEAD5(LATN5), HEAD5(LATS5), AHEAD5(L),
1 AHEAD5(M)
WRITE OUTPUT TAPE JL, 23, (AHEAD5(I), I=L, M)
4022 DO 246 J=LAIN5, LATS5
DO 245 I=1,2
ITEST=0
IC1(I)=KSFA(I,J)
IF (IC1(I)) 233,233,230
230 XIC2(I)=KSFAFMP(I,J)/IC1(I)
XIC2(I)=XIC2(I)/10.0
GO TO 5005
233 XIC2(I)=0.0
ITEST=1
5005 IC3(I)=JDEWF(I,J)
IF (IC3(I)) 235,235,234
234 XIC4(I)=JDEWPT(I,J)/IC3(I)
XIC4(I)=(XIC4(I)-320.0)/18.0
GO TO 5006
235 XIC4(I)=0.0
ITEST=1
5006 IC5(I)=KWIND(I,J)
IF (IC5(I)) 237,237,236
236 IC6(I)=KWINDIRX(I,J)/IC5(I)
IC7(I)=KWINDIRY(I,J)/IC5(I)
GO TO 5007
237 IC6(I)=0
IC7(I)=0
ITEST=1
5007 IC8(I)=KWINDV(I,J)
IF (IC8(I)) 239,239,238
238 XIC9(I)=KWINDVFL(I,J)/IC8(I)
GO TO 5008
239 XIC9(I)=0.0
ITEST=1
5008 IC10(I)=JCLO(I,J)
IF (IC10(I)) 241,241,240
240 CLOUD(I)=JCLOUD(I,J)/IC10(I)
CLOUD(I)=CLOUD(I)/100.0
GO TO 260
241 CLOUD(I)=0.0
ITEST=1
260 IC2(I)=KBAR(I,J)
IF (IC2(I)) 262,262,261
261 BAROM(I)=KBAROM(I,J)/IC2(I)
BAROM(I)=BAROM(I)/10.0
GO TO 5009
262 BAROM(I)=0.0
5009 IF (COUNT(I,J)) 5011,5011,5010
5010 DIFF(I,J)=DIFF(I,J)/COUNT(I,J)
GO TO 5012
5011 DIFF(I,J)=0.0
ITEST=1
5012 IF (XINTF(COUNT(I,J))+IC1(I)) 290,290,291

```

```

291 AIRTEMP(I)=XIC2(I)-DIFF(I,J)
GO TO 292
292 AIRTEMP(I)=0.0
292 KKKK=YKKK+XMAXOF(IC1(I),IC3(I),IC5(I),IC8(I),IC10(I),IC2(I))
IF (JTEST) 5014,5014,5013
5013 QR(I)=0.0
QI(I)=0.0
QF(I)=0.0
QB(I)=0.0
QH(I)=0.0
GO TO 245
5014 IF (XMINOF(IC1(I),IC3(I),IC8(I),IC10(I))-5) 5013,5015,5015
5015 K=XIC2(I)+1.0
X=X-1
L=(XIC2(I)-X)*10.0+1.0
M=XIC4(I)+1.0
X=M-1
N=(XIC4(I)-X)*10.0+1.0
X=FS(L,K)-FS(N,M)
QR(I)=(1.14E-07)*(XIC2(I)+273.0)**4*(0.39-0.050*ES(N,M)**0.5)*
1 (1.0-XK2(J)*CLOUD(I)**2)+(4.56E-07)*(XIC2(I)+273.0)**3*DIFF(I,J)
QR(I)=-QR(I)
QI(I)=HEAT(INO,J)*(1.0-XK1(J)*CLOUD(I)-0.38*CLOUD(I)**2)
QR(I)=QI(I)*REFLECT(N0,J)*(-1.0)
QF(I)=2.41*XIC9(I)*X*(-1.0)
243 QH(I)=-1.58*DIFF(I,J)*XIC9(I)
245 QT(I)=QI(I)+QR(I)+QB(I)+QF(I)+QH(I)
LINE=LINE+1
IF (LINE-6) 5246,5246,9017
9017 TABLE(4)=TABLE(4)+0.001
LINE=1
9018 WRITE OUTPUT TAPE JL, 19,
WRITE OUTPUT TAPE JL, 45, TABLE(4), AMONTH, IYEAR
M=LONGCHK/5
L=M-1
WRITE OUTPUT TAPE JL, 51, HEAD5(LATN5), HEAD5(LAIS5),AHEAD5(L),
1 AHEAD5(M)
WRITE OUTPUT TAPE JL, 23, (AHEAD5(I), I=L, M)
5246 WRITE OUTPUT TAPE JL,30, HEAD5( J ),(XIC2(L),IC1(L),L=1,2),
1 (AIRTEMP(L), IC1(L), L=1,2), (XIC4(L),IC3(L),L=1,2),
2 (PAROM(L),IC2(L),L=1,2), (IC6(L),IC5(L),L=1,2), (IC7(L),IC5(L),
3 L=1,2), (XIC9(L),IC8(L),L=1,2), (CLOUD(L),IC10(L),L=1,2)
WRITE OUTPUT TAPE JL,48, (QI(L),QI(L),QR(L),QB(L),QE(L),
1 QH(L),L=1,2)
246 CONTINUE
C * * * * *
5247 IF (ALPHA(21)-5H*****). 6969,248,6969
C PULL PRECEDING CARD RETURN FOLLOWING CARD
C5247 IF (ALPHA(21)-5H*****). 247,248,247
247 LONGCHK=LONGCHK+10
IF (LONGCHK-LIMLONGE)1035,1035,248
C * * * * *
C BUFFER ERROR ROUTINE
7000 BACKSPACE JK
ICOUNT=ICOUNT+1
IF (ICOUNT-5) 7001,7001,7002
7001 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
GO TO NOT, (6000,6002)
7002 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
GO TO 7001
7003 REWIND JK
JK=JK+1

```

GO TO 7001

\*\*\*\*\*

248 LLLL=KKKK+JJJJ

WRITE OUTPUT TAPE JL, 32, AMONTH, IYEAR, XDATE, IDAY, JYEAR

250 WRITE OUTPUT TAPE JL, 47, LLLL, JJJJ, KKKK, XNAME

281 WRITE OUTPUT TAPE JL, 46, AMONTH, IYEAR, TABLE(1), AMONTH, IYEAR,

1 TABLE(2), AMONTH, IYEAR, TABLE(3)

WRITE OUTPUT TAPE JL, 50, AMONTH, IYEAR, TABLE(4)

271 END FILE JL

IF (MARKT+MARKR) 249, 250, 249

249 END FILE JM

250 STOP

END

IDENT ZERO

ENTRY ZERO

ZERO RTJ \*\*

SAU Z1

LLS 48

SAU Z2

Z1 LIL 6 \*\*

FNA 0

Z2 IJP 6 \*\*

SLJ ZERO

Z2 STA 6 \*\*

SLJ Z3

END

IDENT DOLT

ENTRY DOLT

DOLT RTJ \*\*

SAU DOLT8

LLS 48

SAU \*\*

LIL 6 \*\*

INI 6 -1

DOLT8 LDO \*\*

FNA 0

LOOP LLS 6

JNA -12B

AJP 7 \*\*

AJP P DOLT

FNA 0

IJP 6 LOOP

SLJ DOLT

END

SUBROUTINE CHANGE(I,X)

END FILE I

REWIND I

I=I+1

X=X+15.0

RETURN

END

END RUCOM

FINIS

-EXECUTER.



## APPENDIX B

Tables used in data processing program.



Appendix Table B-1.--Values by month and by latitude of incoming solar radiation with a clear sky. [Adapted from Berliand, 1960.]

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
55N	80	173	355	548	696	761	713	570	398	229	109	58
50N	131	237	411	589	718	774	732	609	450	288	162	105
45N	190	305	464	625	738	784	752	645	497	348	223	162
40N	255	371	514	655	753	789	767	675	539	405	287	227
35N	321	431	559	679	762	789	774	697	578	458	347	290
30N	381	485	597	696	764	784	773	711	612	507	403	349
25N	437	531	627	707	759	774	766	718	641	551	456	405
20N	487	571	652	710	747	759	752	718	663	590	506	458
15N	533	607	672	708	731	737	732	713	681	622	551	507
10N	575	637	688	702	709	708	708	704	693	649	591	553
5N	615	661	700	693	682	674	678	689	700	671	627	597
0N	651	680	706	680	651	637	645	670	700	689	658	637
0S	681	696	706	663	619	599	609	647	693	700	685	675
5S	709	710	699	643	585	558	570	618	679	705	708	710
10S	733	719	687	616	547	513	529	585	659	703	726	740
15S	753	724	670	584	506	467	486	550	635	695	740	764
20S	769	726	650	547	462	419	440	511	571	685	751	784
25S	782	722	625	508	416	372	391	469	539	671	758	802
30S	790	710	595	468	368	323	341	423	540	652	760	816
35S	792	691	559	424	315	269	291	374	502	629	756	826
40S	791	667	520	377	260	211	236	324	461	600	745	831
45S	784	638	477	328	206	153	178	269	416	566	729	828
50S	771	604	430	274	152	100	124	211	367	527	711	818
55S	753	567	380	215	102	54	75	152	310	486	696	808

Appendix Table B-2.--Values by month and by latitude of the percent of incoming solar radiation that is reflected. [Adapted from Budyko, 1956.]

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
55N	.190	.150	.105	.077	.077	.067	.077	.085	.095	.132	.177	.197
50N	.170	.130	.095	.072	.072	.062	.072	.075	.085	.117	.152	.172
45N	.147	.112	.087	.067	.067	.060	.067	.067	.077	.102	.132	.150
40N	.122	.097	.082	.062	.062	.060	.062	.062	.072	.087	.117	.130
35N	.105	.087	.077	.060	.060	.060	.060	.060	.067	.077	.102	.112
30N	.095	.082	.072	.060	.060	.060	.060	.060	.062	.072	.087	.097
25N	.085	.077	.067	.060	.060	.060	.060	.060	.060	.067	.077	.085
20N	.075	.072	.062	.060	.060	.060	.060	.060	.060	.062	.072	.075
15N	.067	.067	.060	.060	.060	.060	.060	.060	.060	.060	.067	.070
10N	.062	.062	.060	.060	.060	.060	.060	.060	.060	.060	.062	.070
5N	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.067
0N	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.062
0S	.060	.060	.060	.060	.060	.062	.060	.060	.060	.060	.060	.060
5S	.060	.060	.060	.060	.060	.067	.060	.060	.060	.060	.060	.060
10S	.060	.060	.060	.060	.062	.070	.062	.062	.060	.060	.060	.060
15S	.060	.060	.060	.060	.067	.070	.067	.067	.060	.060	.060	.060
20S	.060	.060	.060	.062	.072	.075	.075	.072	.062	.060	.060	.060
25S	.060	.060	.060	.067	.077	.085	.085	.077	.067	.060	.060	.060
30S	.060	.060	.062	.072	.087	.097	.095	.082	.072	.060	.060	.060
35S	.060	.060	.067	.077	.102	.112	.105	.087	.077	.060	.060	.060
40S	.062	.062	.072	.087	.117	.130	.122	.097	.082	.062	.062	.060
45S	.067	.067	.077	.102	.132	.150	.147	.112	.087	.067	.067	.060
50S	.072	.075	.085	.117	.152	.172	.170	.130	.095	.072	.072	.062
55S	.077	.085	.095	.132	.177	.197	.190	.150	.105	.077	.077	.067



Appendix Table B-3.--Values for the constant  $\underline{k}$  by latitude used in computation of back radiation. [Adapted from Budyko, 1956.]

55N	50N	45N	40N	35N	30N	25N	20N
0.75	0.73	0.71	0.69	0.67	0.64	0.62	0.60

15N	10N	5N	0N	0S	5S	10S	15S
0.58	0.56	0.53	0.51	0.51	0.53	0.56	0.58

20S	25S	30S	35S	40S	45S	50S	55S
0.60	0.62	0.64	0.67	0.69	0.71	0.73	0.75

Appendix Table B-4.-- Values of saturation vapor pressure over water used in the computation of evaporation. [Adapted from Smithsonian Meteorological Tables, 1958, Table 94, p. 352.]

°C.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>	<u>mb.</u>
0.0	6.11	6.15	6.20	6.24	6.29	6.33	6.38	6.43	6.47	6.52
1.0	6.57	6.61	6.66	6.71	6.76	6.81	6.86	6.90	6.95	7.00
2.0	7.05	7.11	7.16	7.21	7.26	7.31	7.36	7.42	7.47	7.52
3.0	7.58	7.63	7.68	7.74	7.79	7.85	7.90	7.96	8.02	8.07
4.0	8.13	8.19	8.24	8.30	8.36	8.42	8.48	8.54	8.60	8.66
5.0	8.72	8.78	8.84	8.90	8.97	9.03	9.09	9.15	9.22	9.28
6.0	9.35	9.41	9.48	9.54	9.61	9.67	9.74	9.81	9.88	9.94
7.0	10.01	10.08	10.15	10.22	10.29	10.36	10.43	10.51	10.58	10.65
8.0	10.72	10.80	10.87	10.94	11.02	11.09	11.17	11.24	11.32	11.40
9.0	11.47	11.55	11.63	11.71	11.79	11.87	11.95	12.03	12.11	12.19
10.0	12.27	12.36	12.44	12.52	12.61	12.69	12.78	12.86	12.95	13.03
11.0	13.12	13.21	13.30	13.38	13.47	13.56	13.65	13.74	13.83	13.92
12.0	14.02	14.11	14.20	14.30	14.39	14.49	14.58	14.68	14.77	14.87
13.0	14.97	15.07	15.17	15.27	15.37	15.47	15.57	15.67	15.77	15.87
14.0	15.98	16.08	16.19	16.29	16.40	16.50	16.61	16.72	16.83	16.94
15.0	17.04	17.15	17.26	17.38	17.49	17.60	17.71	17.83	17.94	18.06
16.0	18.17	18.29	18.41	18.52	18.64	18.76	18.88	19.00	19.12	19.25
17.0	19.37	19.49	19.61	19.74	19.86	19.99	20.12	20.24	20.37	20.50
18.0	20.63	20.76	20.89	21.02	21.16	21.29	21.42	21.56	21.69	21.83
19.0	21.96	22.10	22.24	22.38	22.52	22.66	22.80	22.94	23.09	23.23
20.0	23.37	23.52	23.66	23.81	23.96	24.11	24.26	24.41	24.56	24.71
21.0	24.86	25.01	25.17	25.32	25.48	25.64	25.79	25.95	26.11	26.27
22.0	26.43	26.59	26.75	26.92	27.08	27.25	27.41	27.58	27.75	27.92
23.0	28.09	28.26	28.43	28.60	28.77	28.95	29.12	29.30	29.48	29.65
24.0	29.83	30.01	30.19	30.37	30.56	30.74	30.92	31.11	31.30	31.48
25.0	31.67	31.86	32.05	32.24	32.43	32.63	32.82	33.02	33.21	33.41
26.0	33.61	33.81	34.01	34.21	34.41	34.62	34.82	35.03	35.23	35.44
27.0	35.65	35.86	36.07	36.28	36.50	36.71	36.92	37.14	37.36	37.58
28.0	37.80	38.02	38.24	38.46	38.69	38.91	39.14	39.37	39.59	39.82
29.0	40.06	40.29	40.52	40.76	40.99	41.23	41.47	41.71	41.95	42.19
30.0	42.43	42.67	42.92	43.17	43.41	43.66	43.91	44.17	44.42	44.67
31.0	44.93	45.18	45.44	45.70	45.96	46.22	46.49	46.75	47.02	47.28
32.0	47.55	47.82	48.09	48.36	48.64	48.91	49.19	49.47	49.75	50.03
33.0	50.31	50.59	50.87	51.16	51.45	51.74	52.03	52.32	52.61	52.90
34.0	53.20	53.50	53.80	54.10	54.40	54.70	55.00	55.31	55.62	55.93
35.0	56.24	56.55	56.86	57.18	57.49	57.81	58.13	58.45	58.77	59.10
36.0	59.42	59.75	60.08	60.41	60.74	61.07	61.41	61.74	62.08	62.42
37.0	62.76	63.11	63.45	63.80	64.14	64.49	64.84	65.20	65.55	65.91
38.0	66.26	66.62	66.99	67.35	67.71	68.08	68.45	68.82	69.19	69.56
39.0	69.93	70.31	70.69	71.07	71.45	71.83	72.22	72.61	72.99	73.39

## APPENDIX C

Sample page copies of data tabulations produced by the  
FORTRAN-62 data processing program listed in Appendix A.

Note: Computer printout labels and sign convention in Table 4.022 differ  
from the text (see p. 17) as follows:

$$1) \quad Q(T) = Q_T,$$

$$Q(I) = Q_I,$$

$$Q(R) = Q_R,$$

$$Q(B) = Q_B,$$

$$Q(E) = Q_E,$$

$$\text{and } Q(H) = Q_H.$$

$$2) \quad Q(T) = Q(I) + [-Q(R)] + [-Q(B)] + [-Q(E)] + [-Q(H)]$$

This equation is equivalent to that given on page 17. The signs in the  
equation and computer output values have been altered to permit proper  
notation of the components (heat loss from sea--negative; heat gain by  
sea--positive).

U.S. BUREAU OF COMMERCIAL FISHERIES  
BIOLOGICAL LABORATORY  
SAN DIEGO, CALIF.

MARINE WEATHER OBSERVATION SUMMARY  
FOR THE  
PACIFIC OCEAN  
FOR THE MONTH OF  
JUNE 1964

DATE OF RUN. . . . . JUNE 30, 1964

NUMBER OF OBSERVATIONS	9241
NUMBER OF REJECTIONS	391
SUMMARIZED OBSERVATIONS	8850

PROGRAMMED BY. . . MARVIN W. CLINE  
PROCESSED BY. . . . . JAMES A. RENNER



TABLE 1.022--SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT) WITH NUMBER OF OBSERVATIONS  
BY ONE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE	LONGITUDE										LONGITUDE RANGE 149W-140W									
	149W	148W	147W	146W	145W	144W	143W	142W	141W	140W										
59N	( 0 )	( 0 )	( 0 )	50 ( 2 )	( 0 )	42 ( 1 )	56 ( 2 )	54 ( 3 )	54 ( 1 )	55 ( 1 )										
58N	45 ( 4 )	49 ( 3 )	41 ( 1 )	( 0 )	( 0 )	( 0 )	( 0 )	47 ( 1 )	( 0 )	49 ( 2 )										
57N	47 ( 5 )	51 ( 3 )	51 ( 3 )	48 ( 2 )	49 ( 3 )	50 ( 1 )	( 0 )	50 ( 1 )	53 ( 1 )	54 ( 3 )										
56N	( 0 )	49 ( 1 )	( 0 )	( 0 )	47 ( 2 )	50 ( 2 )	47 ( 2 )	( 0 )	49 ( 1 )	51 ( 2 )										
55N	46 ( 2 )	( 0 )	47 ( 2 )	( 0 )	53 ( 1 )	45 ( 1 )	( 0 )	50 ( 1 )	46 ( 1 )	50 ( 2 )										
54N	50 ( 4 )	45 ( 2 )	43 ( 1 )	47 ( 3 )	( 0 )	50 ( 2 )	49 ( 2 )	49 ( 3 )	49 ( 1 )	51 ( 2 )										
53N	47 ( 1 )	44 ( 1 )	48 ( 1 )	46 ( 2 )	46 ( 1 )	46 ( 1 )	46 ( 3 )	53 ( 1 )	( 0 )	53 ( 1 )										
52N	46 ( 9 )	46 ( 6 )	46 ( 6 )	47 ( 6 )	46 ( 5 )	48 ( 6 )	48 ( 3 )	49 ( 2 )	49 ( 2 )	46 ( 4 )										
51N	46 ( 3 )	46 ( 7 )	48 ( 5 )	46 ( 8 )	47 ( 10 )	46 ( 6 )	48 ( 9 )	49 ( 6 )	47 ( 5 )	47 ( 5 )										
50N	46 ( 3 )	48 ( 5 )	46 ( 5 )	47 ( 5 )	46 ( 7 )	46 ( 7 )	46 ( 7 )	48 ( 10 )	46 ( 4 )	48 ( 9 )										
49N	46 ( 5 )	48 ( 7 )	47 ( 3 )	48 ( 9 )	46 ( 2 )	51 ( 7 )	47 ( 5 )	49 ( 3 )	50 ( 6 )	50 ( 3 )										
48N	47 ( 3 )	48 ( 3 )	48 ( 2 )	48 ( 4 )	48 ( 4 )	50 ( 1 )	48 ( 4 )	48 ( 5 )	50 ( 2 )	48 ( 5 )										
47N	48 ( 5 )	52 ( 2 )	47 ( 6 )	49 ( 2 )	51 ( 5 )	( 0 )	48 ( 2 )	50 ( 3 )	( 0 )	50 ( 3 )										
46N	52 ( 2 )	50 ( 8 )	52 ( 3 )	( 0 )	49 ( 3 )	55 ( 1 )	50 ( 2 )	54 ( 1 )	48 ( 1 )	53 ( 2 )										
45N	49 ( 6 )	50 ( 3 )	51 ( 10 )	52 ( 7 )	51 ( 10 )	51 ( 9 )	53 ( 8 )	54 ( 5 )	54 ( 3 )	51 ( 5 )										
44N	52 ( 9 )	52 ( 8 )	52 ( 8 )	54 ( 12 )	51 ( 5 )	52 ( 2 )	52 ( 3 )	52 ( 8 )	53 ( 10 )	53 ( 10 )										
43N	53 ( 6 )	54 ( 6 )	52 ( 3 )	54 ( 9 )	52 ( 6 )	53 ( 10 )	54 ( 11 )	55 ( 5 )	54 ( 7 )	49 ( 2 )										
42N	54 ( 7 )	56 ( 4 )	53 ( 4 )	55 ( 4 )	53 ( 5 )	53 ( 4 )	54 ( 7 )	53 ( 6 )	55 ( 10 )	56 ( 9 )										
41N	59 ( 4 )	58 ( 5 )	57 ( 3 )	57 ( 7 )	55 ( 1 )	55 ( 5 )	56 ( 7 )	56 ( 5 )	57 ( 4 )	57 ( 6 )										
40N	58 ( 5 )	59 ( 5 )	58 ( 5 )	60 ( 6 )	59 ( 5 )	59 ( 4 )	58 ( 3 )	60 ( 1 )	59 ( 8 )	55 ( 3 )										
39N	58 ( 3 )	58 ( 5 )	58 ( 5 )	60 ( 5 )	57 ( 3 )	60 ( 6 )	58 ( 9 )	61 ( 5 )	59 ( 9 )	58 ( 4 )										
38N	( 0 )	62 ( 7 )	61 ( 2 )	65 ( 4 )	64 ( 1 )	62 ( 4 )	58 ( 3 )	61 ( 4 )	60 ( 3 )	60 ( 11 )										
37N	62 ( 2 )	62 ( 4 )	61 ( 3 )	61 ( 6 )	61 ( 4 )	61 ( 4 )	61 ( 4 )	62 ( 6 )	60 ( 6 )	62 ( 5 )										
36N	68 ( 4 )	60 ( 1 )	63 ( 4 )	64 ( 1 )	63 ( 7 )	63 ( 2 )	64 ( 6 )	62 ( 6 )	63 ( 5 )	64 ( 5 )										
35N	66 ( 2 )	( 0 )	64 ( 3 )	65 ( 2 )	66 ( 2 )	63 ( 5 )	63 ( 5 )	64 ( 5 )	65 ( 3 )	64 ( 8 )										
34N	70 ( 5 )	65 ( 5 )	66 ( 4 )	66 ( 1 )	65 ( 12 )	61 ( 2 )	66 ( 4 )	66 ( 5 )	64 ( 2 )	65 ( 5 )										
33N	65 ( 1 )	67 ( 2 )	65 ( 4 )	68 ( 5 )	66 ( 1 )	62 ( 3 )	65 ( 1 )	64 ( 3 )	( 0 )	64 ( 1 )										
32N	69 ( 1 )	68 ( 2 )	66 ( 5 )	70 ( 1 )	64 ( 2 )	64 ( 1 )	64 ( 4 )	65 ( 1 )	66 ( 3 )	60 ( 2 )										
31N	69 ( 7 )	67 ( 4 )	67 ( 4 )	67 ( 1 )	( 0 )	69 ( 2 )	67 ( 3 )	67 ( 1 )	( 0 )	66 ( 16 )										
30N	70 ( 2 )	73 ( 1 )	68 ( 2 )	70 ( 1 )	66 ( 1 )	( 0 )	69 ( 4 )	69 ( 11 )	66 ( 15 )	65 ( 2 )										

TABLE 2.058--BAROMETRIC PRESSURES (MILLIBARS), X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED (KNOTS)

WITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE	LONGITUDE	LONGITUDE RANGE 149W-140W											
		149W	148W	147W	146W	145W	144W	143W	142W	141W	140W		
47N	BAR	1014.4	51026.5	11011.2	61018.2	21015.0	6	0	01005.5	21019.0	3	0	01018.1
	X-	3	5	5	7	2	1	0	0	2	3	0	0
	Y-	12	1	1	17	2	6	0	-10	5	3	0	0
46N	BAR	1021.5	21016.4	51020.6	3	0	0	0	0	24	11	0	0
	X-	0	2	9	3	7	3	18	1	1	1	11	2
	Y-	1	5	3	0	0	3	15	1	0	1	-4	2
45N	BAR	1015.6	31009.8	21010.6	11017.6	61017.2	101012.0	81016.7	41016.1	31009.0	31007.6	4	4
	X-	2	3	4	7	11	10	10	8	2	3	1	4
	Y-	3	19	7	3	3	10	3	8	4	3	3	4
44N	BAR	1008.6	71013.8	71021.0	81014.6	111020.2	51014.0	31016.5	31020.1	51015.0	91015.5	7	7
	X-	0	7	3	6	11	5	3	7	3	9	-4	7
	Y-	5	15	-1	6	11	2	1	3	1	9	-8	7
43N	BAR	1008.8	41012.4	61010.7	31015.3	81015.6	51015.7	11018.9	81017.9	41022.1	61023.5	1	1
	X-	-7	4	-1	-1	8	-2	7	10	0	6	-15	1
	Y-	3	2	7	6	8	3	11	4	6	6	0	1
42N	BAR	1014.5	71021.4	41019.3	51021.9	21017.9	31018.3	31004.2	61019.6	51025.6	91016.5	7	7
	X-	7	7	4	5	2	14	10	6	5	0	0	7
	Y-	10	4	8	4	2	0	3	1	5	9	2	7
41N	BAR	1024.1	41020.1	51020.4	21016.6	41013.5	11014.3	61014.6	31025.9	31018.8	51020.7	6	6
	X-	2	4	-4	2	3	-11	0	5	3	2	6	6
	Y-	9	5	13	5	3	9	6	-2	3	0	-4	6
40N	BAR	1015.0	51015.4	31021.0	61022.1	41022.2	41017.8	41025.7	21002.2	11013.9	81016.3	3	3
	X-	4	5	11	10	6	9	7	-5	1	0	3	3
	Y-	2	5	7	11	6	7	4	15	9	3	3	3
39N	BAR	1008.4	31006.9	41010.4	51021.5	31011.1	31022.8	41022.4	101021.5	61020.3	81020.6	3	3
	X-	6	3	10	5	5	0	4	4	6	8	8	8
	Y-	-3	3	8	5	2	10	2	9	6	-1	14	3
38N	BAR	1020.2	71013.0	21022.3	3	0	0	51018.9	31019.1	41023.2	41020.4	10	10
	X-	0	8	4	1	0	7	2	3	4	5	10	10
	Y-	0	0	5	0	0	9	6	3	4	2	10	10
37N	BAR	1022.5	21023.9	41024.2	31024.0	51019.1	31021.3	31021.3	31021.1	61016.3	61025.6	4	4
	X-	6	2	4	3	5	3	9	3	6	3	4	4
	Y-	0	7	-5	3	2	1	1	3	7	2	3	4
36N	BAR	1027.5	4	0	1030.6	31030.1	11024.7	81024.7	31021.0	61022.7	51028.2	5	5
	X-	2	4	0	0	1	5	8	7	6	-5	5	5
	Y-	-7	4	0	1	1	-2	3	3	9	13	9	9

TABLE 3.015--SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT AND CENTIGRADE) AND NUMBER OF OBSERVATIONS  
BY TWO-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LONGITUDE LATITUDE	LONGITUDE RANGE				148W-140W
	148W	146W	144W	142W	
58N	46.6 ( 7) 8.1	46.7 ( 3) 8.2	41.9 ( 1) 5.5	53.3 ( 6) 11.8	51.7 ( 4) 10.9
56N	48.8 ( 9) 9.3	49.8 ( 5) 9.9	48.8 ( 8) 9.3	47.9 ( 3) 8.8	52.1 ( 7) 11.2
54N	47.6 ( 8) 8.7	46.2 ( 6) 7.9	49.3 ( 4) 9.6	49.2 ( 6) 9.6	49.5 ( 6) 9.7
52N	45.6 ( 17) 7.6	46.6 ( 15) 8.1	47.1 ( 13) 8.4	48.1 ( 9) 8.9	47.8 ( 7) 8.8
50N	46.4 ( 18) 8.0	46.7 ( 23) 8.2	46.4 ( 30) 8.0	47.9 ( 32) 8.8	47.1 ( 23) 8.4
48N	47.1 ( 18) 8.4	47.6 ( 18) 8.7	49.2 ( 14) 9.6	48.0 ( 17) 8.9	49.1 ( 16) 9.5
46N	50.0 ( 17) 10.0	48.4 ( 11) 9.1	50.8 ( 9) 10.4	49.8 ( 8) 9.9	50.6 ( 6) 10.3
44N	50.8 ( 26) 10.4	52.1 ( 37) 11.2	51.1 ( 26) 10.6	52.8 ( 24) 11.6	52.6 ( 28) 11.4
42N	54.3 ( 23) 12.4	53.4 ( 20) 11.9	52.6 ( 25) 11.4	53.9 ( 29) 12.2	54.4 ( 28) 12.4
40N	58.3 ( 19) 14.6	58.0 ( 21) 14.4	57.3 ( 15) 14.1	56.1 ( 16) 13.4	57.2 ( 21) 14.0
38N	59.8 ( 15) 15.4	60.6 ( 16) 15.9	59.8 ( 14) 15.4	59.4 ( 21) 15.2	59.3 ( 27) 15.2
36N	63.9 ( 11) 17.7	61.5 ( 14) 16.4	62.2 ( 17) 16.8	62.1 ( 22) 16.7	62.0 ( 21) 16.7
34N	67.0 ( 12) 19.4	65.1 ( 10) 18.4	64.4 ( 21) 18.0	64.7 ( 19) 18.2	64.3 ( 18) 17.9
32N	67.5 ( 6) 19.7	66.7 ( 15) 19.3	63.7 ( 7) 17.6	64.3 ( 9) 17.9	63.6 ( 6) 17.6
30N	69.0 ( 14) 20.6	67.7 ( 8) 19.8	68.0 ( 3) 20.0	68.4 ( 19) 20.2	66.3 ( 33) 19.1
28N	72.6 ( 5) 22.6	71.0 ( 23) 21.7	70.3 ( 32) 21.3	70.2 ( 25) 21.2	69.6 ( 15) 20.9
26N	73.2 ( 23) 22.9	73.5 ( 27) 23.1	72.3 ( 13) 22.4	72.2 ( 6) 22.3	69.9 ( 7) 21.1
24N	73.8 ( 17) 23.2	74.3 ( 2) 23.5	74.3 ( 2) 23.5	73.4 ( 4) 23.0	72.9 ( 2) 22.7
22N	74.9 ( 3) 23.8	75.2 ( 1) 24.0	72.9 ( 2) 22.7	72.5 ( 1) 22.5	74.5 ( 4) 23.6
20N	75.7 ( 5) 24.3	75.6 ( 9) 24.2	75.8 ( 6) 24.3	76.1 ( 5) 24.5	74.6 ( 3) 23.7
18N	76.3 ( 8) 24.6	75.1 ( 2) 23.9	.0 ( 0) .0	.0 ( 0) .0	.0 ( 0) .0
16N	77.7 ( 4) 25.4	75.6 ( 2) 24.2	75.6 ( 2) 24.2	75.1 ( 2) 23.9	76.0 ( 3) 24.4
14N	76.7 ( 3) 24.8	78.8 ( 1) 26.0	78.8 ( 1) 26.0	78.4 ( 5) 25.8	77.5 ( 2) 25.3
12N	78.8 ( 1) 26.0	.0 ( 0) .0	80.6 ( 1) 27.0	80.6 ( 1) 27.0	81.5 ( 1) 27.5
10N	80.6 ( 5) 27.0	82.4 ( 1) 28.0	.0 ( 0) .0	.0 ( 0) .0	80.1 ( 2) 26.7
8N	82.4 ( 1) 28.0	.0 ( 0) .0	81.9 ( 2) 27.7	.0 ( 0) .0	.0 ( 0) .0
6N	84.2 ( 2) 29.0	.0 ( 0) .0	82.1 ( 3) 27.8	81.9 ( 2) 27.7	80.3 ( 3) 26.8
4N	.0 ( 0) .0	80.6 ( 2) 27.0	.0 ( 0) .0	.0 ( 0) .0	81.9 ( 2) 27.7
2N	82.4 ( 1) 28.0	80.6 ( 1) 27.0	.0 ( 0) .0	80.1 ( 2) 26.7	.0 ( 0) .0
0N	.0 ( 0) .0	.0 ( 0) .0	78.8 ( 1) 26.0	79.7 ( 1) 26.5	81.8 ( 3) 27.7

TABLE 4.022--SEA SURFACE TEMPERATURES (DEGREES CENTIGRADE), AIR TEMPERATURES (DEGREES CENTIGRADE), DEW POINT TEMPERATURES (DEGREES CENTIGRADE), BAROMETRIC PRESSURES (MILLIBARS), X- AND Y-WIND VECTORS (KNOTS), AVERAGE WIND SPEEDS (KNOTS), CLOUD COVER (TENTHS OF SKY COVERED), AND HEAT BUDGET (CALORIES/CENTIMETER-SQUARED/DAY), WITH NUMBER OF OBSERVATIONS BY FIVE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE		LONGITUDE		LATITUDE RANGE		LONGITUDE RANGE	
59N		145W		55N- 25S		145W-140W	
SEA TEMP		8.9 { 34}					
AIR TEMP		11.0 { 29}					
DEW PT		17.2 { 20}					
BAROM		1011.2 { 31}					
X-		-3 { 31}					
Y-		-3 { 31}					
VEL		15 { 20}					
CLOUDS		82 { 20}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-45 50					
234		311 -21 -61					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		203					
30N							
SEA TEMP		8.0 { 106}					
AIR TEMP		9.3 { 106}					
DEW PT		7.4 { 94}					
BAROM		1011.7 { 113}					
X-		1 { 113}					
Y-		1 { 113}					
VEL		13 { 113}					
CLOUDS		95 { 99}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-43 26					
169		214 -13 -43					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		172					
45N							
SEA TEMP		9.5 { 114}					
AIR TEMP		10.6 { 114}					
DEW PT		8.6 { 93}					
BAROM		1014.2 { 110}					
X-		4 { 110}					
Y-		3 { 110}					
VEL		13 { 110}					
CLOUDS		93 { 101}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-51 23					
181		249 -15 -51					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		184					
40N							
SEA TEMP		12.6 { 142}					
AIR TEMP		13.7 { 142}					
DEW PT		11.1 { 111}					
BAROM		1016.8 { 123}					
X-		4 { 124}					
Y-		4 { 124}					
VEL		14 { 109}					
CLOUDS		86 { 109}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-66 24					
206		309 -19 -66					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		198					
35N							
SEA TEMP		16.5 { 80}					
AIR TEMP		17.9 { 80}					
DEW PT		14.4 { 67}					
BAROM		1020.8 { 74}					
X-		2 { 74}					
Y-		2 { 74}					
VEL		11 { 70}					
CLOUDS		80 { 70}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-71 24					
224		337 -21 -71					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		191					
30N							
SEA TEMP		19.4 { 74}					
AIR TEMP		20.2 { 74}					
DEW PT		17.0 { 57}					
BAROM		1019.3 { 73}					
X-		0 { 73}					
Y-		0 { 73}					
VEL		12 { 71}					
CLOUDS		66 { 71}					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		-93 15					
275		468 -28 -93					
Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)		140					







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